ASTRONOMY

NOVEMBER 1976

$1.50

Performance is the First Reason You're Proud to Own a Criterion

In telescopes, "excellence is as excellence does." Our Criterion instruments, with unsurpassed optics, rank among the world's most widely praised, because they perform brilliantly, reliably and with satin-smooth, effortless ease. The more demanding the conditions of use, the more you appreciate the ability of your Criterion to deliver exciting results. Whichever advanced design telescope you select, you get a superbly engineered instrument, guaranteed unconditionally. When you compare the pleasantly surprising prices you find further reason to choose Criterion. Please note that they are not "base" prices, but include everything described AT NO EXTRA COST. Only Criterion's leadership in efficient, modern precision production makes these prices possible.

Dynamax® 8 8-Inch Schmidt-Cassegrain

For Spectacular Results—Effortlessly.
Extra Features Without Extra Price.

This "never before" telescope created by Criterion gives you Schmidt-Cassegrain advantages at their best: full 8" aperture, wide field, with flawless resolution, yet weighs only 30 pounds for one-hand portability! It offers unprecedented versatility for viewing, superb telephotography, terrestrial uses, or technical applications. The exquisite optics, combined with super-precise electric drive plus variable drive corrector, combine to insure unsurpassed, unequalled ease of use because the extra features so necessary for superior results are designed-in and built-in... and INCLUDED in the price! ☐ AC, DC, and manual drives (variable, not just solar). You can easily dial in lunar, solar, sidereal, planetary etc. rates while observing for extra long monitoring. ☐ Large 8x50 finderscope has micrometer screw focusing ☐ Toggle switch with pilot light ☐ Engraved setting circles, observable from viewing position ☐ 3 eyepieces included ☐ Star diagonal, latitude adjusters, photo and telextender adaptors, and custom, fitted case. Ready for Total Performance with nothing else to buy!

As described, complete. FOB Hartford, Conn.
Shipping wt. 65 lbs. Express charges collect.

$875

Dynascope® RV-6 6-Inch Newtonian

For Exciting Viewing, Superb Value.
Price Includes Built-In,
Precision Electric Drive!

Professionals and astute amateurs and school or college users by the thousands know the breathtaking performance, this pace-setting telescope achieves. ☐ Exquisite optical system includes f8 parabolic aluminized mirror, guaranteed to reach all theoretical limits of resolution and definition ☐ Highly accurate Electric Drive uses regular AC, has smooth, self-acting clutch, permits manual operation ☐ Two 1¼" eyepieces, 70X and 140X, included. (others available) ☐ Highly stable equatorial mount with solid tripod, adjusts easily for any latitude ☐ Engraved setting circles for both right ascension and declination ☐ Tube rotates for adding cameras and comfortable viewing. Easy, quick portability ☐ Smooth, brass rack-and-pinion focusing ☐ Handsome, white 50" Bakelite tube maintains perfect collimation ☐ 6x30 finderscope ☐ Fine workmanship throughout.

As described, complete.
FOB Hartford, Conn. Shipping wt. 77 lbs.
Express charges collect, $15 crating charge.

$229.95

Prompt shipment on both models. If you wish, phone us for delivery date.
To place your order, or request literature, write or call:

Criterion Manufacturing Company

Dept. CAS-48 620 Oakwood Ave., W. Hartford, Conn. 06110/Phone: (203) 247-1696
In New York, Robert T. Little, Eastern Sales Manager (212) 834-1888

COSMOS 1977

A new art reprint calendar from ASTRONOMY

Cosmos 1977 carries into its fourth year a tradition started when ASTRONOMY magazine was born — to provide you the most visually stunning view of the universe possible.

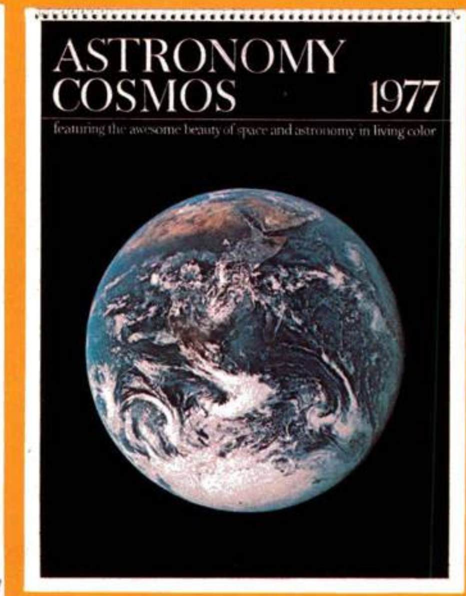
This year's calendar brings our promise to you in its ultimate form. Cosmos 1977 is a collection of 13 full color varnished reproductions of some of the best cosmic art and photographs that have appeared in ASTRONOMY. From the surface of the red planet Mars and glowing tail of comet West, to worlds beyond at the heart of a distant star cluster, the colorful, pictorial universe is displayed in a format that "begs" that the subjects be framed.

Each illustration, printed on coated 80 lb. paper, is surrounded by a 1/4" white border for greater ease in framing. As with last year's calendar, complete framing instructions are provided. Cosmos 1977 is spiral bound and hole punched so that the calendar may be conveniently hung. (Both hole and wire spiral are within the white border away from the illustrations.)

Hallmarks of ASTRONOMY's quality and beauty epitomize this distinctive calendar whether the illustrations are framed immediately or the calendar hung and used throughout the year.

January 1977

S	M	T	W	T	F	S
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23 30	24 31	25	26	27	28	29



ASTRONOMY
COSMOS 1977
featuring the awesome beauty of space and astronomy in living color

Exciting Features Include:

- **Full color, varnished art & photos**
- **Framing instructions provided**
- **Punched for hanging**
- **Planet oppositions & special sky events noted**
- **Room to jot birthdays and other appointments**
- **1977 Calendar**

An Outstanding Christmas Gift

only $4.50 each

(Include 75¢ per order for shipping & handling.)

We will start shipping orders for COSMOS 1977 on Monday, Nov. 15, 1976.

ASTRONOMY

411 E. Mason St., 6th Floor,
Milwaukee, WI 53202

Please send me ________ copies of ASTRONOMY's Cosmos 1977.
Enclosed is ________ (including 75c for shipping and handling).

Send check or money order to:
ASTRONOMY
411 E. Mason St., 6th Floor
Milwaukee, WI 53202

Date: ________

Name ________ (Please Print)

Address ________

City ________ State/Prov. ________ Zip ________

Cave ASTROLA

HERE'S WHY NEWTONIAN REFLECTORS ARE YOUR BEST TELESCOPE VALUES.

American Made — Nationally Available on Extended Payment Terms.

10″ ASTROLA DELUXE NEWTONIAN $925

8″ LIGHTWEIGHT DELUXE f/4.5 and f/14 DUAL CAPABILITY $595

8″ f/7 DELUXE NEWTONIAN $720

WHY YOU CAN'T HAVE EVERYTHING IN A TELESCOPE . . .

Many advertising dollars have been spent by the makers of very compact, folded optical-path telescopes that require a field correction lens along with the reflecting mirror. These short length instruments are highly portable. We agree there's a place for them in some amateur astronomy pursuits, as well as nature study and photography—but we think it's about time to cut through the colorful haze generated by advertising claims, and talk turkey about performance.

When we say "performance," we mean, bluntly, the quality of the image you see or photograph through your telescope —be it binary stars, a moon detail or the rings of Saturn. If you look into the matter, you'll find facts to back up the following:

Aperture for aperture, you can not obtain a folded-path. corrected field telescope, either mass produced or custom designed, that will come close to matching the performance of a well-made conventional Newtonian reflector.

Besides that, the simple Newtonian system, despite its superior image quality, will cost you less. If you haven't seen our catalog you may also be surprised to find that some Astrola 8″, 10″ and even 12½″ reflectors in the shorter focal lengths are remarkably easy to transport and set up in field locations—not for bird-watching, but for serious astronomical observation.

The facts of life are just as real in the optical world as in any other. No one telescope will give you everything—that's why we build 42 different models. You can't have maximum portability with maximum performance. Astrola telescopes are custom built and hand-crafted to give you superior image quality. That's what Cave Optical Company has offered for more than a quarter-century.

Call us if you want to talk about telescopes—we'll make no claims we can't support. The three fine instruments pictured are popular models from our new Silver Anniversary Catalog. Send for yours and learn all about Astrolas before you make important purchase decisions.

ASTROLA NEWTONIAN REFLECTORS
(Selected from more than 40 available models and sizes)

6″	Student Standard	**$ 280.00**
	Student Deluxe	**$ 385.00**
	Model "A" Deluxe	**$ 565.00**
8″	Lightweight Standard	**$ 370.00**
	Lightweight Deluxe	**$ 595.00**
	Model "B" Standard	**$ 460.00**
	Model "B" Deluxe	**$ 720.00**
10″	Model "C" Standard	**$ 590.00**
	Model "C" Deluxe	**$ 925.00**
12½″	Transportable	**$1475.00**
	Permanent-Pier Observatory	**$2490.00**
16″	Permanent-Pier Observatory	**$4490.00**

Exclusive distributors of MAGNUSSON setting circles and CARLE Photo-Visual Focusers and CARLE Camera Adaptations.

ACT NOW!

to take advantage of our 60-day Silver Anniversary Sale. To celebrate our 25th year, we are offering a straight 10% discount on most ASTROLA models and accessories. Don't miss the telescope bargains of the decade! Limited time only. Prices shown in this ad are before discount.

SEND $1.00 ($2.00 FOREIGN) CURRENCY OR STAMPS FOR YOUR 25TH SILVER ANNIVERSARY 30-PAGE COLOR CATALOG A1976

CAVE OPTICAL COMPANY
4137 E. ANAHEIM STREET
LONG BEACH, CALIFORNIA 90804
Telephone 213-434-2613

Factory showroom open Tuesday through Saturday — 9 A.M. to 5 P.M.

ASTRONOMY

The World's Most Beautiful Astronomy Magazine

November 1976 Vol. 4, No. 11

PUBLISHER and EDITORIAL DIRECTOR
Stephen A. Walther

EDITORIAL
Managing Editor
Penny Oldenburger

Technical Editor
Richard Berry

Editorial Assistant
Henry J. Phillips

Staff Associate
Mary Jane Lamers

Contributing Editors
James Mullaney
James E. Oberg
Gerrit L. Verschuur

GRAPHICS
Production Manager
David A. Schwartz

CIRCULATION
Subscriber Relations
Rosemary L. Pickart

COMMUNICATION
Information Officer
Penny Oldenburger

6 THE SPACE TELESCOPE
by George B. Field
16 MARS PICTORIAL
22 STELLAR FRONTIERS
Black Holes, White Holes and Wormholes
by John Gribbin
28 GAZER'S GAZETTE
Doubles, Binaries and Multiple Stars
by Henry J. Phillips
34 PHOTOGRAPHY IN ASTRONOMY
Astrographic Cameras
by Richard Berry
42 SKY ALMANAC
Jupiter Dominates November Sky
50 EQUIPMENT ATLAS
Schmidt Cameras
by Robert Pike
55 ASTRO-NEWS
62 ASTRO-MART
67 GUIDE TO BACK ISSUES
68 PLANET FINDER — NOVEMBER 1976
70 IN FOCUS
73 NOVEMBER STAR DOME
by James Mullaney and Henry J. Phillips
75 Close-Up on the Cetus Region

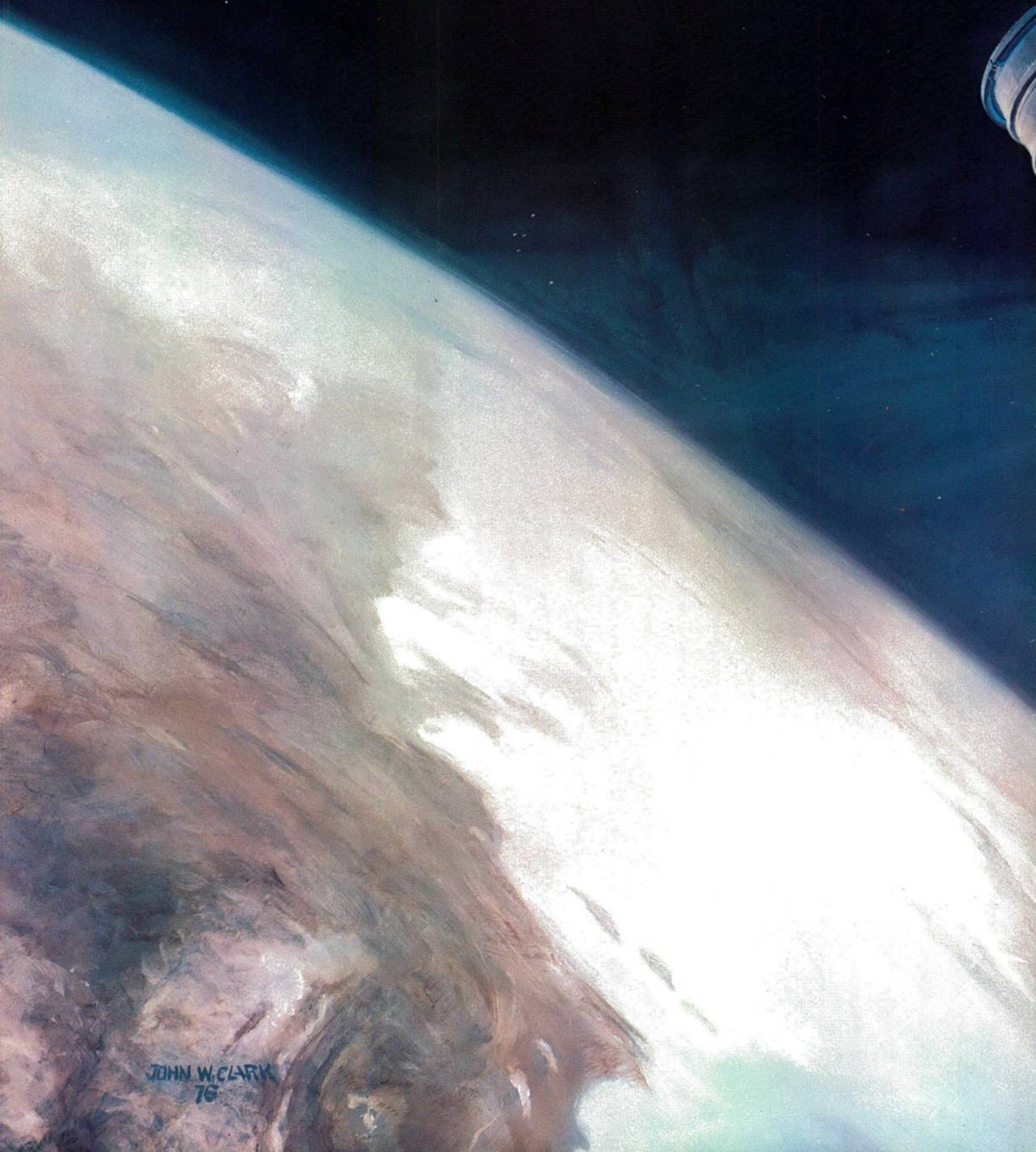
Cover

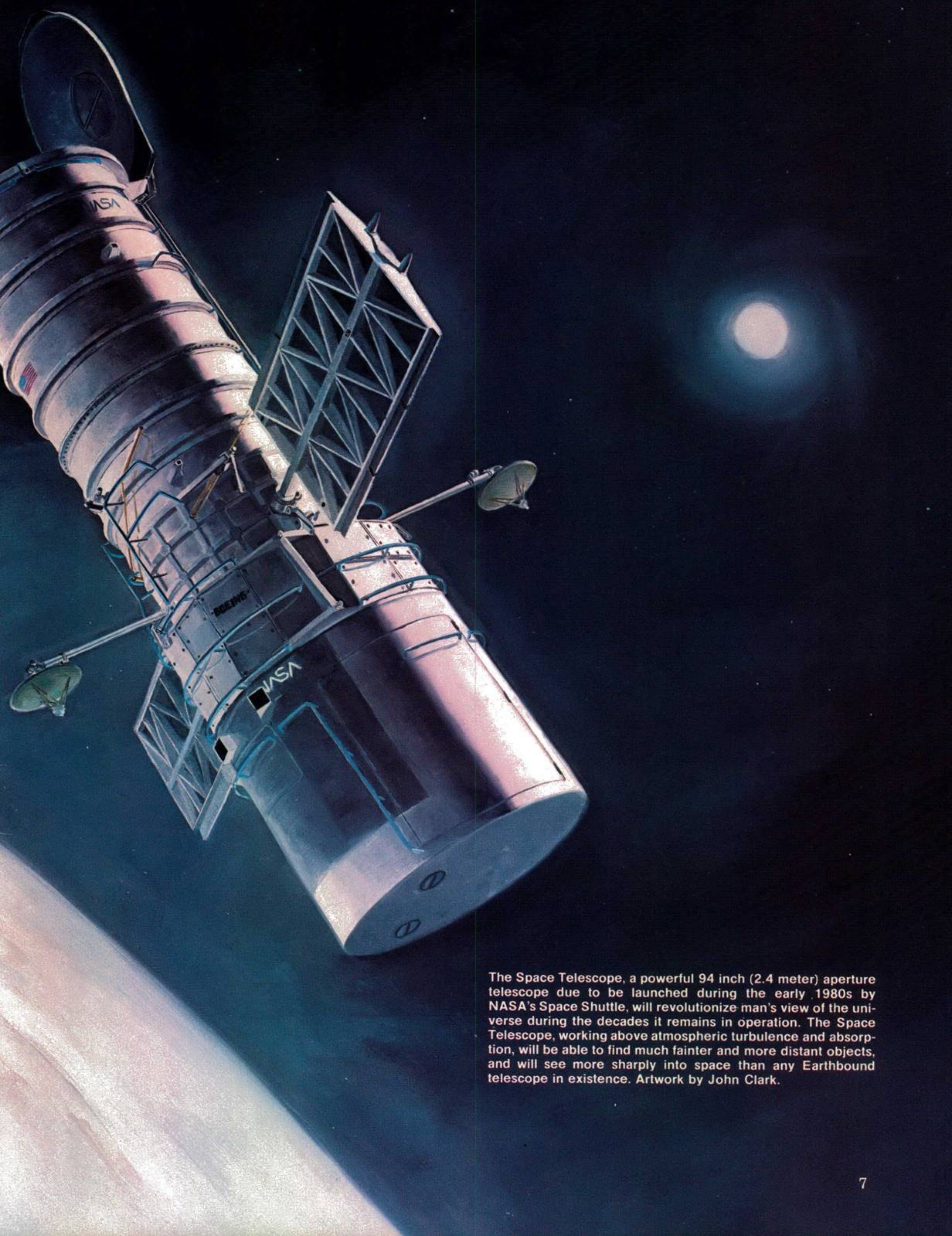
High in the November sky is M-33, a spiral galaxy in Triangulum. The most distant known member of the Local Group of galaxies, M-33 has less than five percent as many stars as the Milky Way. Although its visual magnitude is 5.8 (technically visible to the naked eye), the galaxy is so diffuse that it is difficult to observe satisfactorily except with low power. Long exposure photographs reveal more of its open spiral shape; the proposed Space Telescope — the subject of ASTRONOMY's lead article this month — could provide photographs at least 10 times more detailed even than those obtainable with the 200 inch telescope at Mount Palomar. This issue of ASTRONOMY also includes discussions on black holes, double stars — and, of course, reports on the continued investigation of the surface of Mars by Viking. Photograph by Evered Kreimer.

Published monthly by AstroMedia Corp., 411 E. Mason St., 6th Floor, Milwaukee, WI 53202. Copyright © 1976 by AstroMedia Corp., all rights reserved. No part of this issue may be reproduced by any mechanical, photographic or electronic process, or otherwise copied for public or private use without written permission of the publisher. Second class postage paid at Milwaukee, Wisconsin. POSTMASTER: When undeliverable, send form 3579 to publisher. Direct all new subscriptions, changes of address, renewals and subscription bill payments only to ASTRONOMY, Circulation Services, P.O. Box 186, Westchester, IL 60153 and allow six to eight weeks for new subscriptions and changes of address to take effect. To speed service on subscription correspondence, complaints, photographs, slides, manuscripts and editorial correspondence write ASTRONOMY, 411 E. Mason St., 6th Floor, Milwaukee, WI 53202. Telephone (414) 276-2689. Due to the limited availability of back issues, new subscriptions must start with the most current month's issue. Cover price, $1.50. Subscription price: 1 year, $12.00. Canada & Mexico: add $3.00 per year. All other foreign: add $6.00 per year. Additional office staff: William Stanfield, Production Assistant; Katherine King, Editorial Secretary; Stephanie Kiel, Administrative Assistant; Nancy Faustmann, Executive Secretary and Bulk Copy Sales. Accountant: Peter Trabbold. Consulting Editors: Thomas C. Bretl, John Harmon. Contributing Artists: John W. Clark, Victor Costanzo, Mark Paternostro, Adolf Schaller. ADVERTISING REPRESENTATIVES: Western Region — J. E. Publishers' Representative Co., 8732 Sunset Blvd., 4th Floor, Los Angeles, CA 90069; (213) 659-3810. Eastern Region — J. E. Publishers' Representative Co., 527 Madison Ave., New York, NY 10022; (212) 355-6875. Typesetting by Grafilm, Inc., Milwaukee, WI 53210. Separations prepared by Colorcraft, Inc., Milwaukee, WI 53216. Printed by E. F. Schmidt Co., Menomonee Falls, WI 53051.

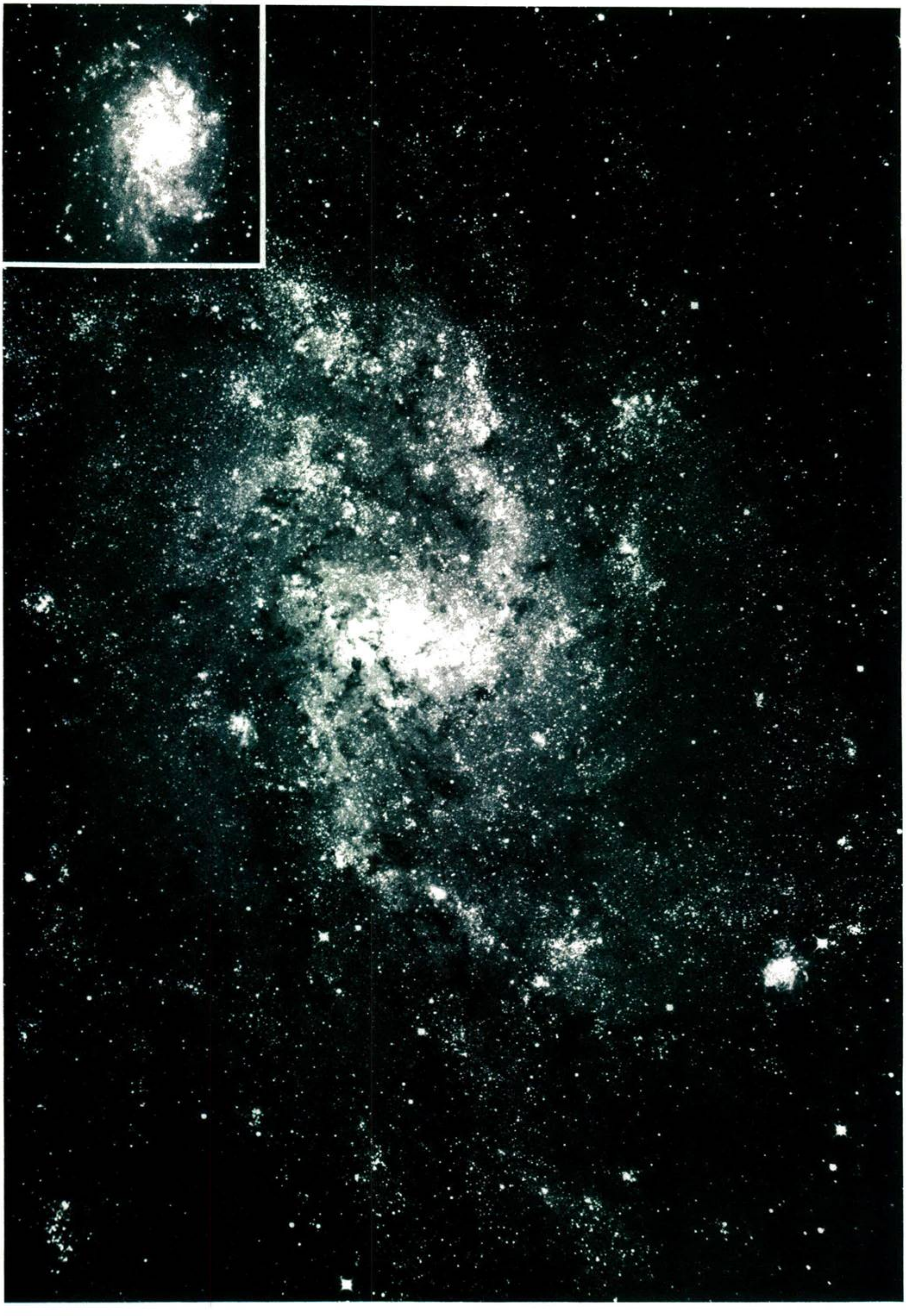
THE SPACE TELESCOPE

by
George B. Field


JOHN W. CLARK
76



The Space Telescope, a powerful 94 inch (2.4 meter) aperture telescope due to be launched during the early 1980s by NASA's Space Shuttle, will revolutionize man's view of the universe during the decades it remains in operation. The Space Telescope, working above atmospheric turbulence and absorption, will be able to find much fainter and more distant objects, and will see more sharply into space than any Earthbound telescope in existence. Artwork by John Clark.



If you could build the observatory of your dreams, what features would it have?

First, and most important, is that you'd probably want a pretty big optical instrument. Although discoveries with specialized detectors are exciting, nothing really compares with sharp, detailed photographs of astronomical objects. The beauty, mystery and joy of astronomy still lie in seeing the stars.

How good could these pictures be? Twice as good as those possible with the famous Hale 200 inch telescope? Use your imagination! Remember this is a dream instrument . . . make the resolution 10 or 20 times better!

In fact, since this is a dream telescope, there's no Earthly reason to limit your view to the narrow band of visible light. The unexplained mysteries of other wavelengths can be explored. Make your ideal observatory sensitive to ultraviolet, infrared, and even millimeter and submillimeter bands, too.

Of course, no dream observatory should ever have "down time" because of weather, so you'll want a location free from rain and snow, haze and pollution, water vapor and jet contrails. Indeed, you could even eliminate the atmosphere. Once atmospheric turbulence is gone, your telescope will be limited only by unavoidable diffraction, since the instrument would have nearly perfect optics.

Climbing to the top of a cold, oxygen-thin mountain in some remote, unpopulated part of the world is inconvenient, so why not locate the controls in your own backyard? Work your astronomical miracles in your shirtsleeves in a warm, well-lit room (no dark adaptation needed here) with nearly instantaneous retrieval of data. In fact, if anything goes wrong with the telescope or its associated instruments, you could send a team of trained technicians to fix it.

And, since this is a dream observatory, you might as well go all the way and give it 24 hour capability: The sun will never rise, the moon will always be dark, and the stars will always shine.

Although such an ideal observatory may be beyond the reach of an individual, as a member of the astronomical community you may see the dream become reality.

The Space Telescope (ST) — proposed by NASA for flight aboard the Space Shuttle of the 1980s — will be such a dream observatory. The ST promises both professional and amateur astronomers the first unobscured views of the heavens — views of unprecedented clarity and detail.

Imagine that the photograph at upper left was the best available picture of M-33. Although excellent by amateur photography standards, details remain frustratingly hidden. Meaningless blobs of light, however, suddenly come alive in the larger photo with 10 times the resolution, revealing much more information about this spiral galaxy. Now imagine a photograph with 10 times greater resolution than that in the larger photo! The structure of dust lanes would be clarified, individual stars resolved, and vastly improved physical studies would result. The Space Telescope would provide just such a photo. Upper left: Photograph by Robert Provin; Large photograph by Lick Observatory.

Unaffected by atmospheric turbulence, the ST will concentrate visible light from a point source into an image only 0.1 seconds of arc in diameter — 10 times sharper than the best images now available from the ground. Without atmospheric absorption, the ST can observe across a wide range of the electromagnetic spectrum, from optical to ultraviolet, infrared to submillimeter. The unique combination of clear images and vast spectral range holds promise for the expansion of astronomy in many fields — particularly in observational tests of many cosmological theories that now intrigue and baffle both professional and backyard stargazers. Indeed, the ST represents an improvement in observing techniques equal to what has been achieved in the entire history of telescope development.

What Is the Space Telescope?

A space telescope was first conceived 30 years ago. It wasn't until the beginning of the Space Age and the launch of Orbiting Astronomical Observatories that the idea gained serious consideration as a national project. In 1972, NASA's Marshall Space Flight Center was chosen to develop a large optical instrument for space orbit. The past four years have been spent in producing preliminary designs, identifying costs and methods of control, and developing schedules — all in working with professional astronomers and major industrial teams.

During this long development process, the ST has undergone many changes of its own. One early design called for a throwaway satellite with a telescope of 1.5 meters aperture; another considered a three meter system attended and operated by a man in orbit. As the Space Shuttle emerged, the final design of a space telescope became more clear. Astronomers agreed that the telescope should be operated from the ground, but that man would perform the launch, repair and recovery. The size of the telescope aperture was established at 2.4 meters (about 100 inches) — a size that reduced the technological risks of manufacture and permitted less costly pointing systems, while maintaining a resolving power much greater than that possible from the ground.

Scientific teams also defined what the "dream telescope" was supposed to do. Astronomers wanted the instrument to be long-lived and versatile, that is, able to accomodate a variety of scientific instruments — at least four — that would be interchangeable over a period of time.

With a resolution of 0.1 seconds of arc, the telescope could pinpoint objects 10 to 20 times smaller than those visible from Earth's surface. The scientists wanted it to work efficiently at wavelengths permitting study of the important

Scientific Instruments

The key instrument aboard the ST will be a *Focal Plane Camera*, using a televisionlike detector to convert an image to electronic signals for transmission to the ground. A single exposure on the brighter part of a galaxy over one "orbital night" of 30 minutes will reveal 26th magnitude stars. By combining 10 or more images on the ground, utilizing computer techniques, background stars of 29th magnitude — stars more than 100 times fainter than Earthbound telescopes can reach — would be recorded.

The camera can also record portions of the sky *simultaneously* (during the operation of any other instrument) in its "serendipity mode" in order to make accidental discoveries producing a collection of high resolution images at random parts of the sky. Faint objects never before seen (such as extremely distant galaxy clusters) may be found, or — perhaps more exciting — new, totally unanticipated objects.

Other scientific instruments on board the ST will include the *Faint Object Spectrograph* (FOS) and the *Faint Object Camera* (FOC). Coupled with a photon-counting detector, the FOS can measure the spectrum of a 25th magnitude star at low resolution in 10 hours — a feat far beyond the ability of ground based telescopes. These observations will exceed those of any previous instrument in the ultraviolet, including the UV detectors of the Copernicus Orbiting Astronomical Observatory.

The FOC, operating at a focal ratio of f/48 or f/96, will retain the telescope's full angular resolution. Thus, a 10 hour exposure, perhaps spread over many observing sessions, will allow measuring the brightness of 28th magnitude stars to an accuracy of 0.1 magnitude.

Other instruments in planning include an *Infrared Photometer* (IP) covering the *entire* infrared and submillimeter spectrum from 1 to 100 degree microns — from just beyond vision to wavelengths that are nearly considered radio.

Another important instrument, the *Planetary Camera* (PC) — if operated at f/96 — would have a field of view nine seconds of arc square. It could enable us to obtain the first really sharp images of Uranus and Neptune. Operating at f/24, the PC could also observe extremely distant, highly redshifted galaxies.

Of course, although launching delicate objects into space is risky in itself, the planners of the ST have a magnificent advantage: The ST is specifically designed for launch and recovery by the manned Space Shuttle. Thus, it will be possible to operate it for at least 10 years (perhaps much longer), enabling us to spread out the costs accordingly. Since the ST can be serviced by shuttle crews, with components being replaced or repaired in space or, if need be, returning the entire ST to Earth for refurbishing, it conceivably could operate indefinitely.

hydrogen Lyman-alpha line at 1216 Angstroms, and to permit observations in the infrared as well. Most important, the instrument should be able to measure objects much fainter than those accessible from the ground — at 27th magnitude, with a signal-to-noise ratio of 10 in four hours of observing time.

As currently planned, the ST is a full-fledged orbiting astronomical observatory that meets all these criteria. It consists of three major elements: the Optical Telescope Assembly (OTA), the Support Systems Module (SSM), and the Scientific Instruments (SI). The OTA is essentially the telescope, the SSM, the mounting and support system, and SI, the means for converting telescope images into useful scientific data. The entire spacecraft measures approximately 4 meters (13 feet) in diameter and about 13 meters (45 feet) in length. Fully equipped, it will weigh between 7,000 kilograms (15,400 pounds) and 9,000 kilograms (19,800 pounds).

Telescope Optics

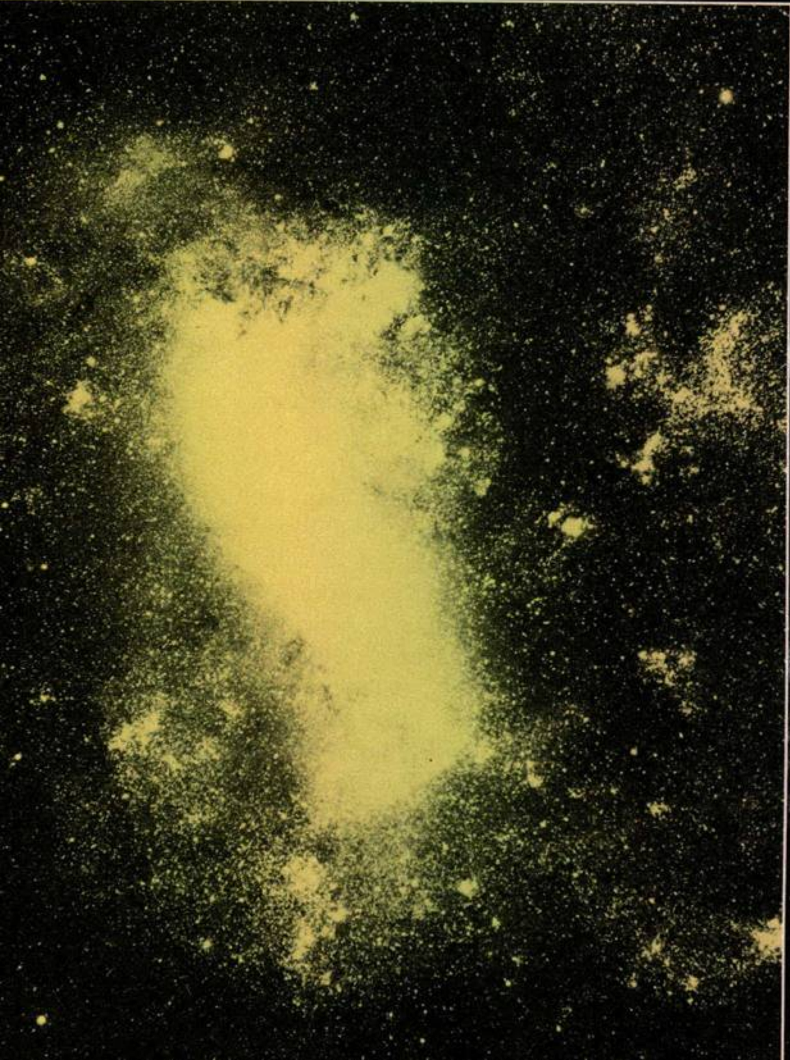
The heart of the ST is a familiar optical design, for it is a 2.4 meter Cassegrain of the Ritchey-Chretien type with a f/2.3 primary and a focal length of f/24.

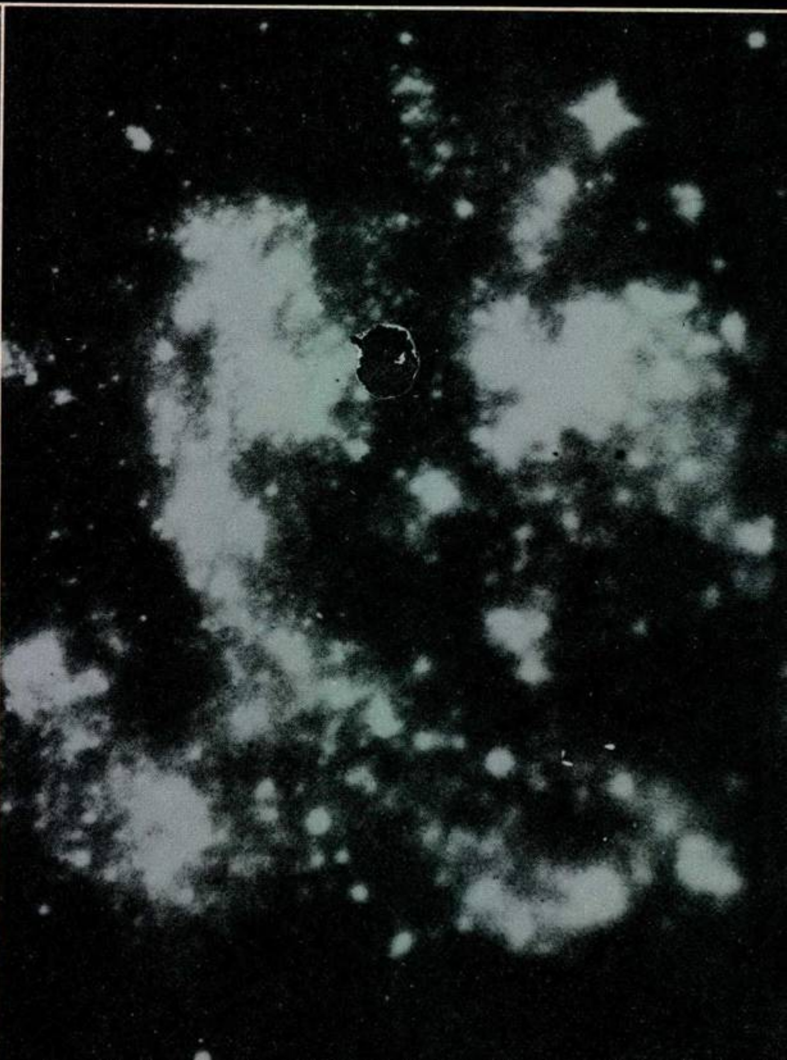
The optics are two lightweight, ultralow-expansion fused silica mirrors in an arrangement that is a lot like conventional reflectors. Light enters the open end of the telescope, is projected onto the smaller secondary mirror and, from there, is deflected to the scientific instruments for analysis. Data from these devices is transmitted to Earth in digital form. The various scientific instruments share the same image plane, with that plane divided into five parts. Four of these parts feed images into instruments on the optical axis, but the fifth instrument is mounted lengthwise and is fed by a central-beam diverting mirror. Since none of the instruments use more than a section of the total image plane, no compromise in seeing is necessary. Moreover, the multiple feed arrangement allows the on-axis camera to observe simultaneously with at least one other instrument.

A Ritchey-Chretien image is characterized by field curvature and astigmatism; however, the outer field images have the same high quality as those in the center, so they can be used for position and guidance determination. Thus, bright stars outside the "scientific data field" will provide signals to a guidance sensing system accurate to 0.007 seconds of arc.

Light shades make observations possible under a wide range of sky conditions, including illumination from the sun, moon and Earth. Stretching far beyond the secondary mirror, these shades, plus a

Upper, inset: Frustratingly fuzzy in this photograph with a 12 inch telescope, M-64 is tantalizingly abnormal, but its nature remains hidden. Photograph by August Schug. Upper: With the increased resolution of the Mount Wilson 60 inch reflector, a strange dust lane explains the appearance of this galaxy, but raises more questions than it answers; studies of the stellar content of such abnormal galaxies will be possible with the Space Telescope. Hale Observatory photograph. Lower left: In visible light we see the Large Magellanic Cloud primarily by the light of its normal stars. The bright "bar" is mainly stellar in content. Yerkes Observatory photograph. Lower right: By contrast, in the far-ultraviolet, very hot, blue stars and highly excited gaseous nebulae are seen. The Space Telescope will combine high resolution with far-ultraviolet capability — a great advance for astronomers studying these objects. Naval Research Laboratories photograph, taken on the moon by Apollo 16.





Left: The giant elliptical galaxy known as M-87 in the Virgo cluster is surrounded by a halo of several thousand globular clusters (at least 20 times as many as our own galaxy has). Yet even with the 200 inch telescope, their images are too indistinct to measure accurately; their nature may be found with the ST. Right: A group of galaxies that appear to interact could provide vital clues about galactic structure if observed at high resolution. Hale Observatories photographs.

folding door at the front end, permit observations within 45 degrees of the sun. In addition, it's possible to block out stray light below the darkest regions of the natural background (the zodiacal light) for about 50 percent of each orbit.

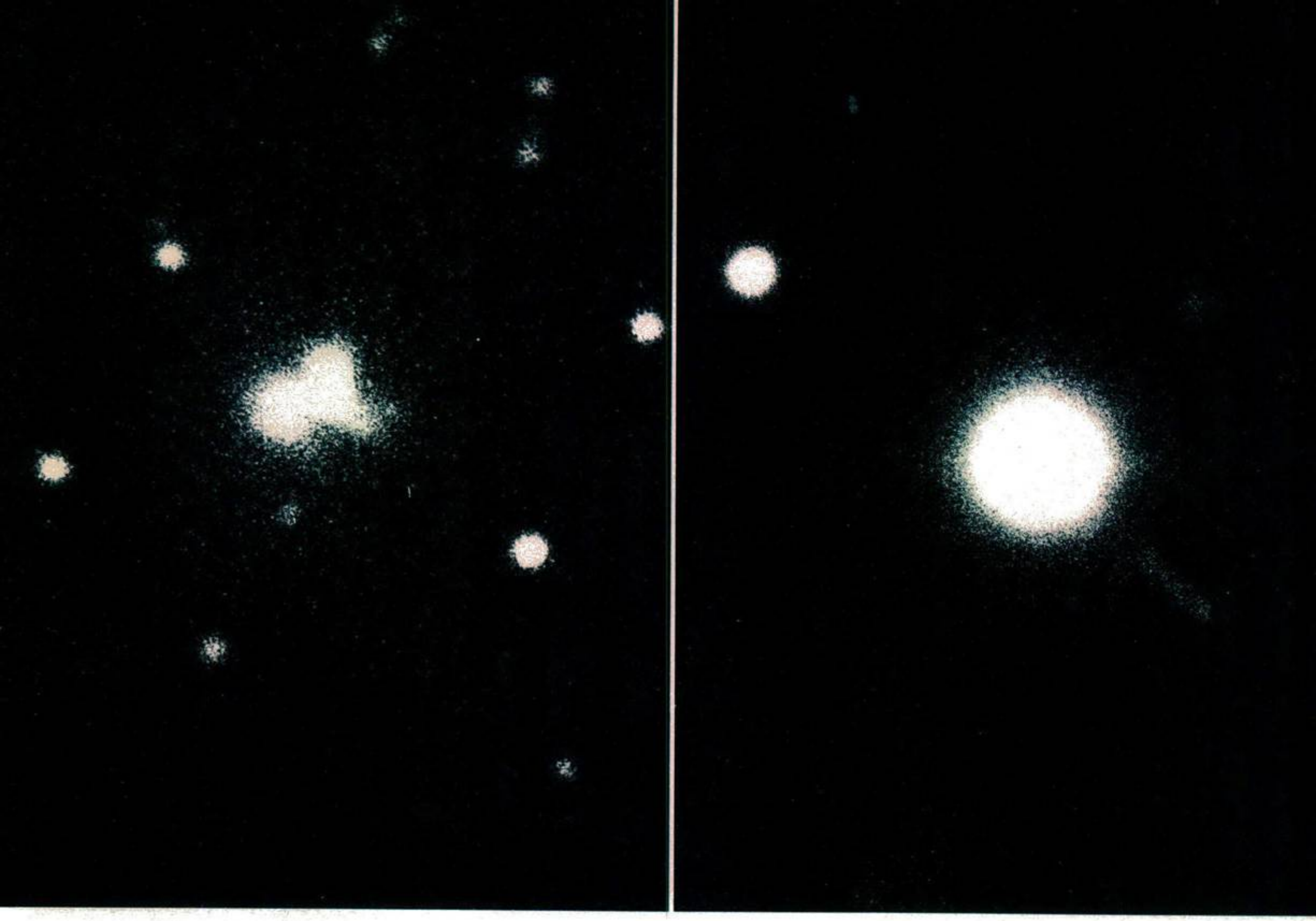
Space Astronomy

Modern research astronomers need the ST. During the past two decades, our understanding of stellar evolution has expanded immensely, but astronomers are still unable to adequately explain the physics and evolution of galaxies. Even our own galaxy — its chemical evolution and the dynamics of its central region — remains largely a mystery.

Essential to understanding galaxies is an accurate distance scale. Distances to "nearby" stars are known because Earth's motion around the sun causes them to shift back and forth a tiny amount. By measuring their brightness and distance, their true luminosity is known. Cepheid variables — their distances painstakingly measured *inside* our galaxy — are calibrated to measure the distances to the distant galaxies. But, the accuracy of these measurements always has been limited by atmospheric interference.

The high angular resolution will permit a great increase in the accurate determination of stars' parallax — and thus greater accuracy in the distances measured. Once an accurate new distance to the Hyades star cluster in Taurus is found, astronomers will have a standard for determining distances to new star clusters, based on the brightness of the Hyades' "main sequence" stars. Similarly, if enough distances to nearby, very old stars (Population II) are found, a similar main sequence for old stars can be constructed. Astronomers may even be able to fit the ancient, metal-deficient stars of globular clusters into the sequence.

Extending the astronomical distance scale will offer new evidence for a solution to the problem of the expanding universe. Astronomers should be able to accurately measure the rate of expansion and discover if the expansion is uniform in space and time. Observations of galaxies and intergalactic matter may yield an accurate measurement of the average density of matter in the universe — very important in determining whether expansion can continue forever or whether it must eventually stop. Based on such observations, the ultimate fate of the universe — infinite expansion or eventual collapse — may become known to man.



Left: Cygnus "A" is a very distant but intense radio source, but its nature is not known. Originally thought to be two galaxies in collision, it is still enigmatic two decades after discovery. Hale Observatories photograph. Right: The brightest quasar, 3C-273, may be a galaxy with a superactive exploding core that has ejected the "jet" at lower right. However, the starlike image of the quasar itself blots out the galaxy to Earthbound telescopes. Hale Observatories photograph.

Observations of stars 100 times fainter than is now possible with the best ground based telescopes might enable the Cepheid variables in the Virgo cluster of galaxies (and more luminous stars as far out as the Coma cluster) to be used in supremely accurate distance measurements. In addition, astronomers may study star formation in galaxies outside our own: The Magellanic Clouds may reveal that star formation occurs in bursts rather than at a steady rate.

In other nearby galaxies, stellar evolution could be studied in detail. Differences recently observed between globular clusters of the Andromeda galaxy and the globular clusters of the Milky Way may be understood.

Ultraviolet spectroscopy of a wide range of galaxies from the oldest to newest will allow the chemical evolution of galaxies to be followed. As they observe ancient objects billions of light-years distant, astronomers can reconstruct galactic evolution right back to its beginnings. Using the sharp images produced by the ST, astronomers could distinguish between types of distant galaxies. A detailed comparison between nearby and distant galaxies may show the universe does indeed "age" as it evolves.

Exciting observations will be made of quasars. Although observed, studied, analyzed and debated, their basic nature remains mysterious today, lost in fuzzy Earthbound telescope images. We do not know where quasars obtain their energy, and we do not understand their interaction with matter surrounding them in space. Particularly intriguing high-redshift quasars show absorption lines in their spectrum at several *different* redshifts, usually smaller than the redshift of the quasar itself. Astronomers think that the absorption lines come from great blobs of gas ejected from their centers, but no one knows if this same phenomenon occurs in low-redshift objects. The spectral lines involved are not shifted from the ultraviolet to the visible range, as they are in high-redshift quasars. With the ultraviolet capability of the ST, it will be possible to study absorption lines in low-redshift quasars, and to verify once and for all whether the absorbing gas is being ejected, or substantiate the belief that true inter galactic gas is in the space between us and the quasar.

Quasars, themselves, may be the results of violent explosions in the centers of galaxies. Cer-

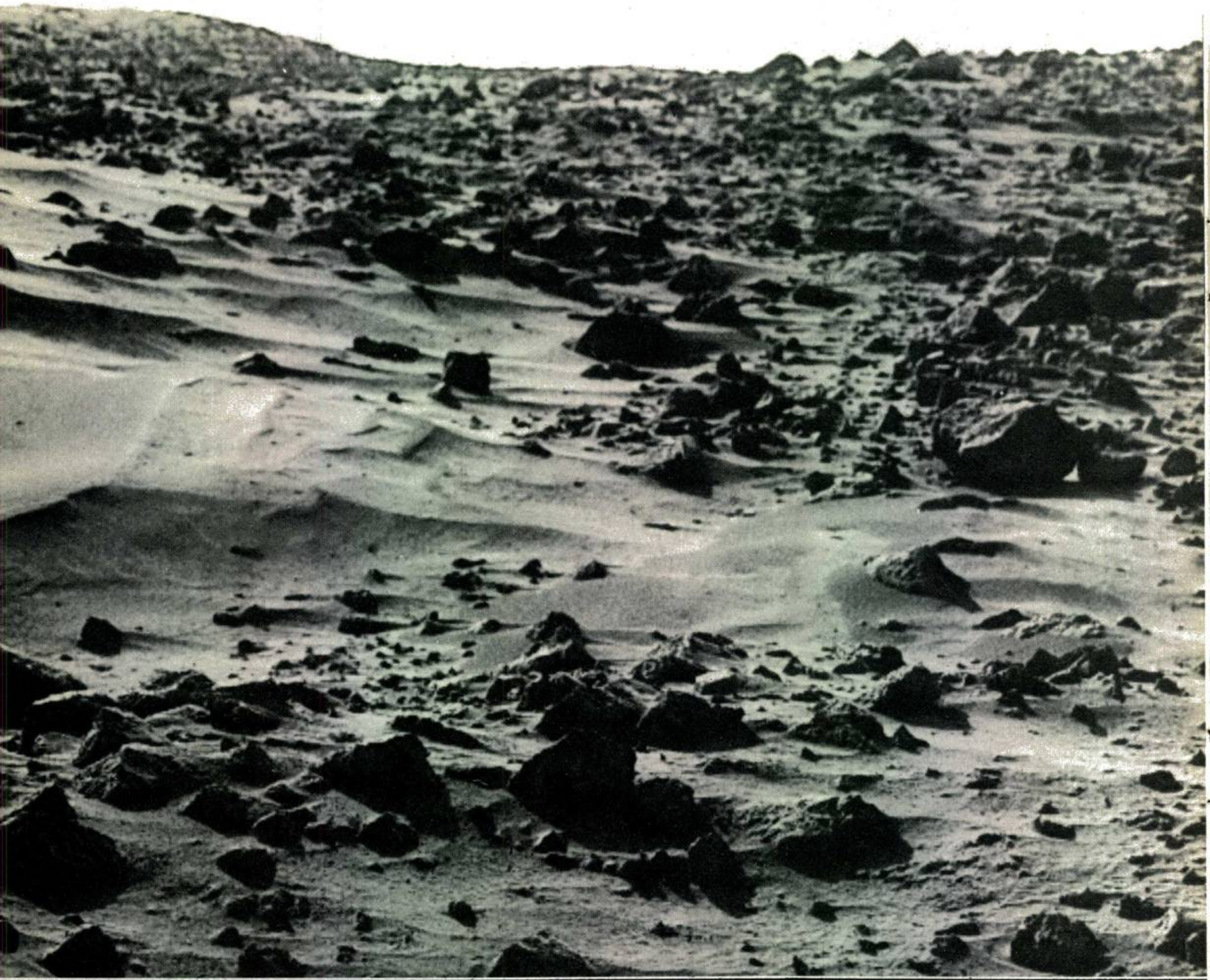
Left: After several years of operation in space, an equipment failure might occur on the Space Telescope. However, repairs could be performed by astronauts visiting it by Space Shuttle, as is portrayed here. The Shuttle and Space Telescope are joined in "soft dock" to allow the astronaut shown approaching the instrument section of the telescope to test and replace failed systems. Artwork by Adolf Schaller. Above: A small nearby galaxy, NGC-205 (one of the companions of M-31 in Andromeda), is resolved into stars in this picture taken with the 200 inch telescope. The Space Telescope could extend this type of resolution at least 10 times deeper into space. Hale Observatories photograph.

tainly, the activity of quasars is similar to the behavior seen in the nuclei of some other galaxies. In understanding the true nature of quasars, observations in the ultraviolet and infrared will disclose the spectrum of these objects over an enormous wavelength range, thus constraining theoretical models of energy production. Observations in the ultraviolet will help tie down the chemical composition, and hence the history, of the quasars. Most exciting, however, is that use of the full angular resolution of the ST may reveal whether, as many astronomers believe, the quasars are really superbright galactic nuclei. Present observations from the ground do not permit a firm conclusion on this point, because the bright — but blurred — quasar images swamp those of the galaxies in which they may be embedded. Sharp pictures with the ST, on the other hand, will confine quasar images to a small region and permit astronomers to study surrounding galaxies if they are there.

The ST is intended as a prime optical instrument and as a complementary tool in the arsenal of other space instruments planned for the 1980s. The optical and ultraviolet capabilities of the ST will support x-ray investigations by the High Energy Astronomy Observatories and, in turn, these instruments will be complemented by airborne and balloon-borne infrared telescopes and large ground based radio telescopes now under development.

According to present plans, ST research will be directed by a special Space Telescope Science Institute, managed by an independent university consortium. The orbiting observatory will be operated as a national facility similar to the Kitt Peak National Observatory, with time available for special studies by guest investigators. Although it is unlikely that amateur astronomers — either as individuals or in groups — will share in the direct use of the telescope, they will certainly share the excitement of discovery anticipated with the operation of this dream telescope.

George B. Field is director of the Center for Astrophysics (Cambridge, Mass.), a joint research facility combining the staffs and resources of the Harvard College Observatory and the Smithsonian Astrophysical Observatory. He serves as director of both observatories and as professor of astronomy at Harvard University.

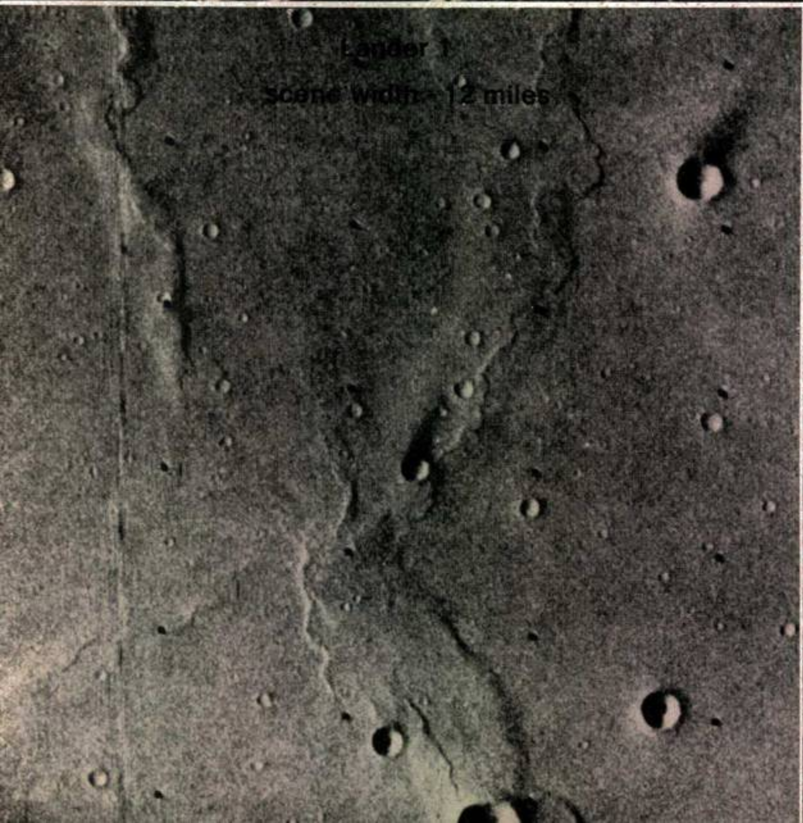


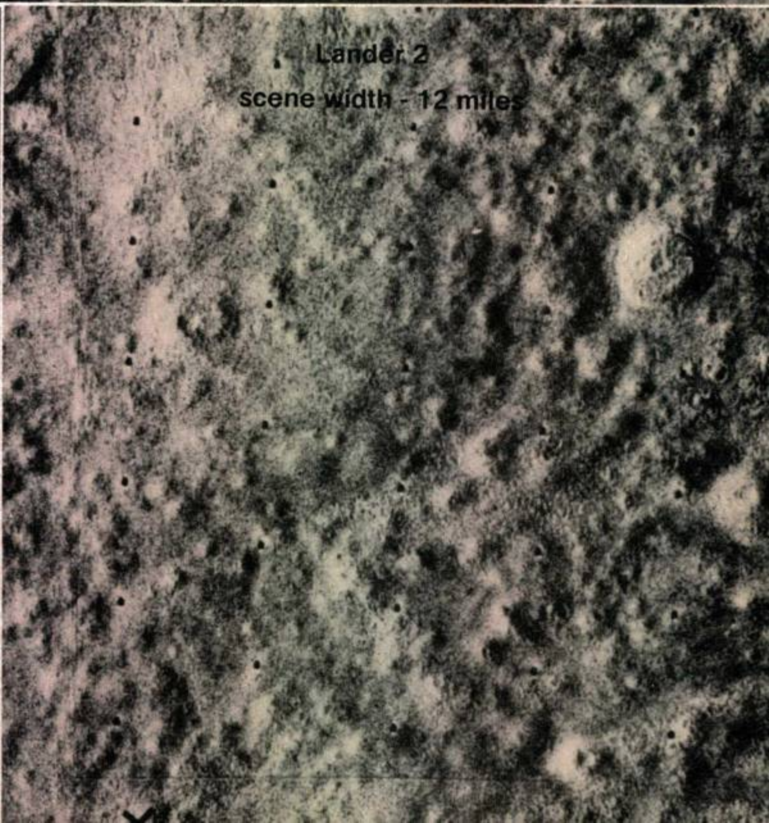
MARS PICTORIAL

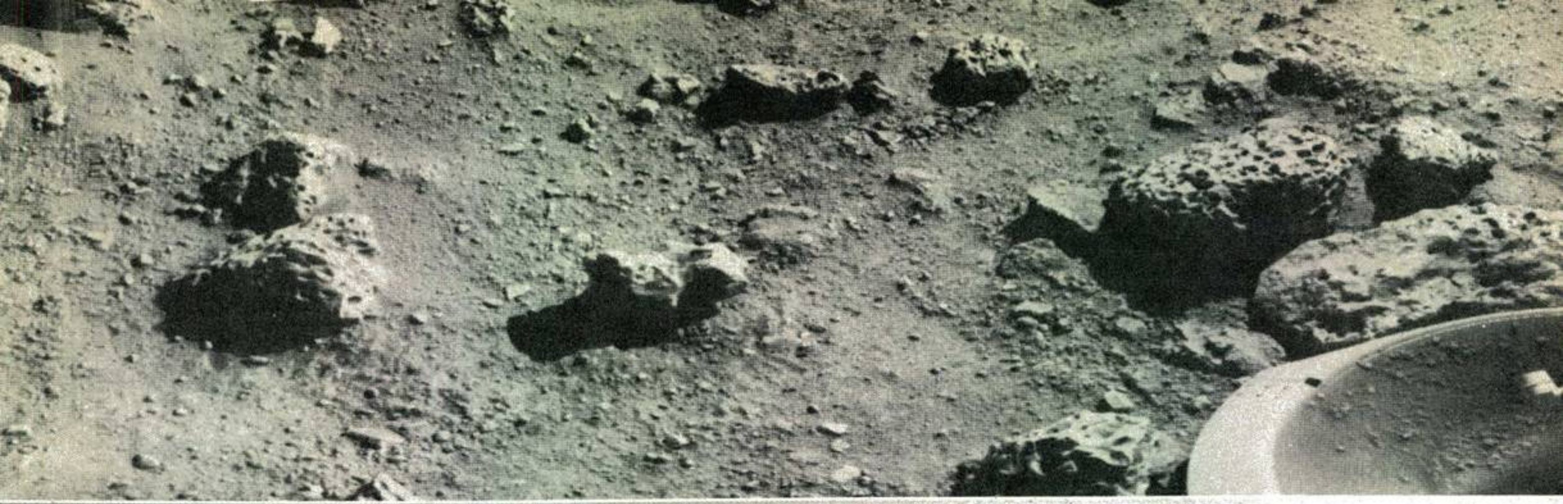
With the safe and successful arrival of Viking Lander 2 on the Utopia Planitia (plains) of Mars, the Viking mission is "go" for complete success of the most complex space mission ever attempted. If all goes well, Viking scientists will have at least two years to explore in detail two sites on another planet.

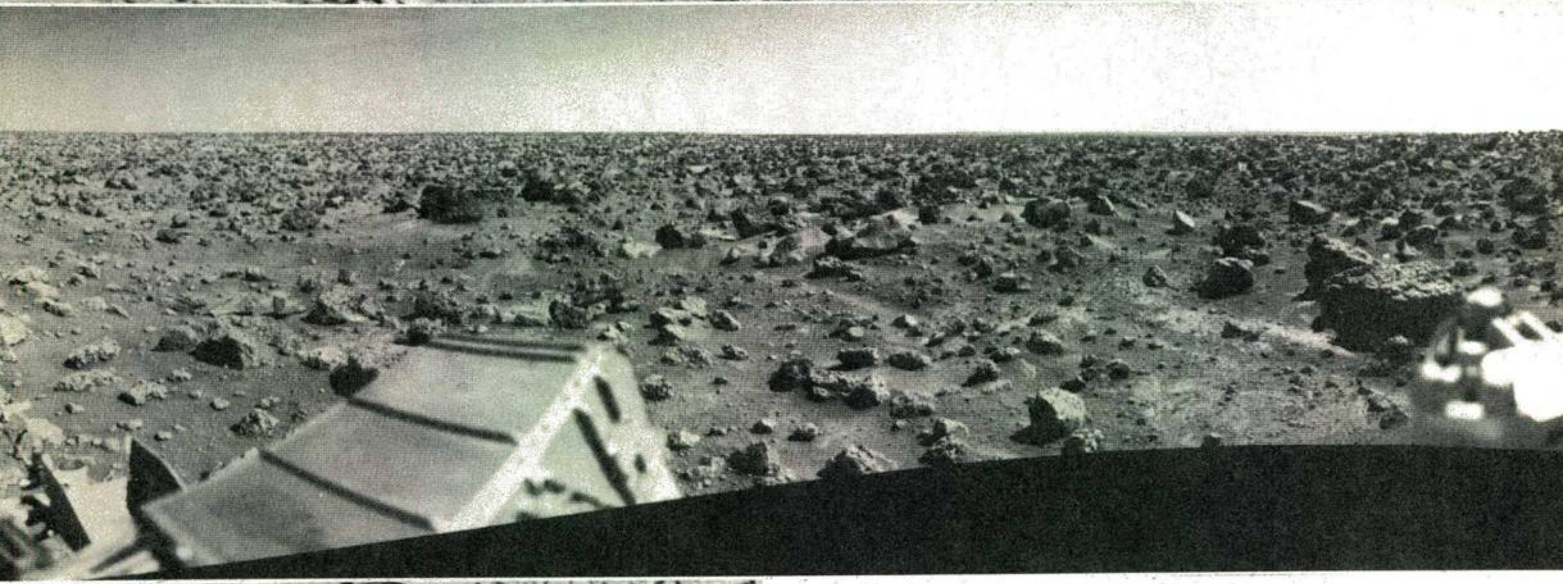
Utopia Planitia, like the Chryse Planitia, is a low region with more water than most of Mars;

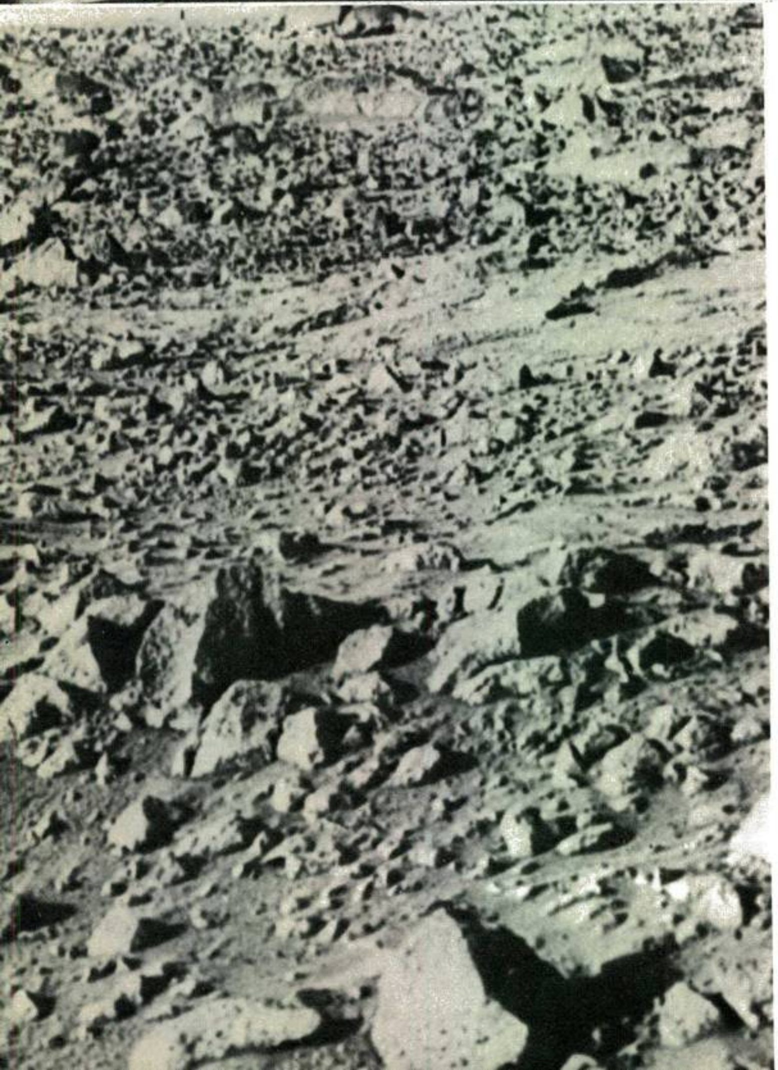
Above: The dramatic early morning lighting of the Martian landscape — taken two hours after sunrise on the 14th day after Viking I's landing — highlights a Mars surface of sand and rock closely resembling some terrestrial deserts. The sun is about 27 degrees high, slightly to the left of the edge of the picture. Downwind from rocks are seen short wind tails (see "Searching for Mars on Earth", October 1976, for terrestrial comparisons) which indicate wind direction. The dunefield at left is adjacent to the Mars scene shown in October. Opposite: The landing sites of the two Landers looked quite different from orbit — that of Lander 1 (left) very smooth, and Lander 2 (right) apparently quite lumpy — but both proved to be rocky plains. NASA photographs.


Lander 1
scene width - 12 miles


Lander 2
scene width - 12 miles

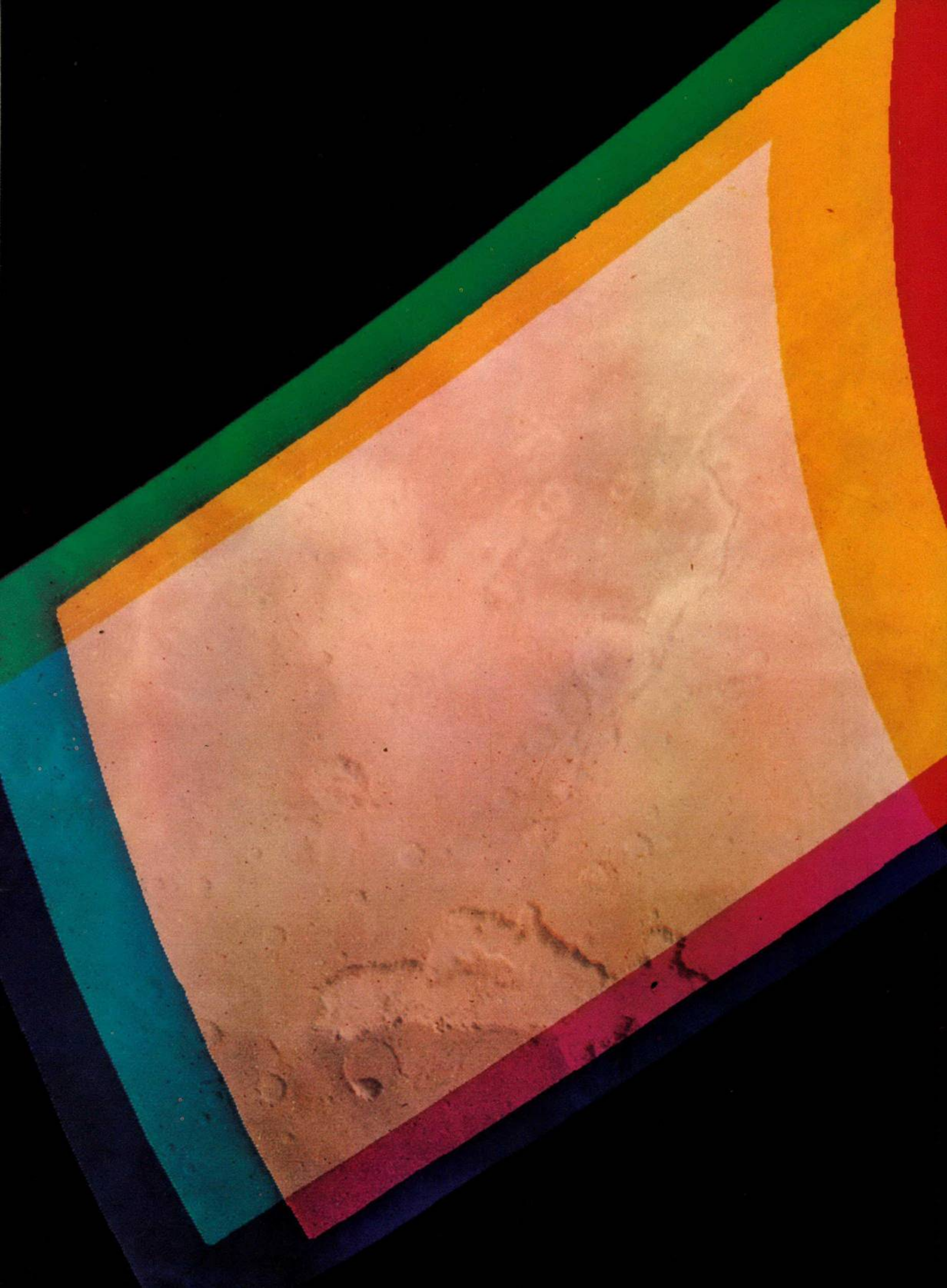


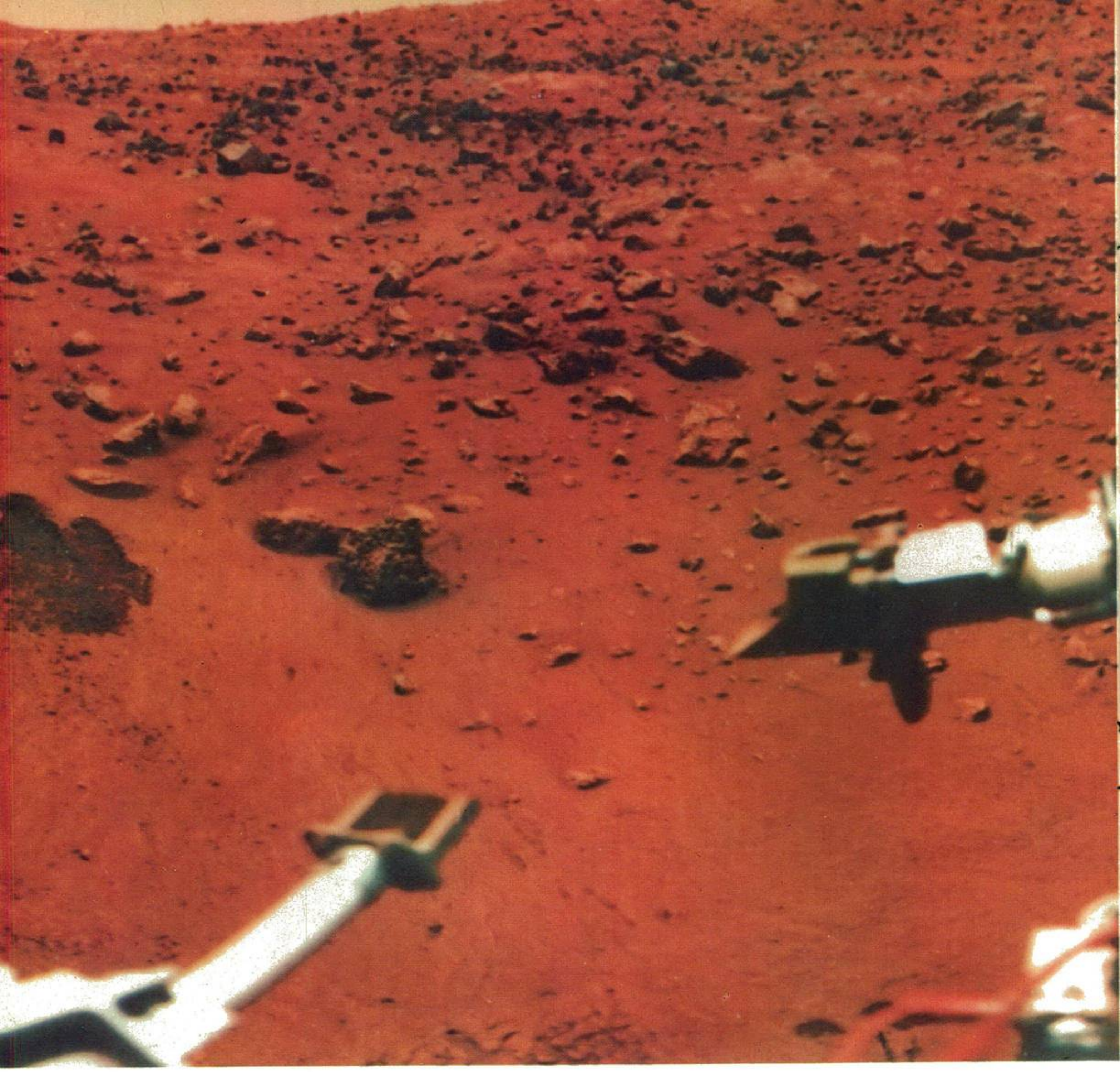




moreover, Utopia has three or four times more water than the Chryse site, enhancing the chances for life detection. Scientists had expected a very sandy dune-covered surface at Utopia, and were surprised that the surface turned out to be quite rocky. In

Top: The first picture taken by Lander 2 covers the same field as Lander 1's first picture — a downward-looking view of footpad 3 by camera 2, and the region to the left of the footpad. Vesicular (hole-filled) rocks of probably volcanic origin lie on a fine granular surface. Rocks are up to eight inches (20cm) long in this view. Center: Lander 2 obtained an immediate panoramic view, as did Lander 1. Here, about 150 degrees of horizon in a northerly direction are shown. The surface is flat, the sand dunes expected from the orbital pictures are not present, and thousands of rocks stretch to the horizon in an apparently uniform distribution. Left: Numerous angular blocks of rock lead from the Lander 1 site to the horizon some 1.8 miles (3km) distant. The largest rocks, such as the one on the horizon, are about 10 feet (3 to 4 meters) across; the smallest visible are a fraction of an inch (about a centimeter). Between the rocky blocks, the surface is composed of a fine sandlike material. Opposite page: The eastern end of Vallis Marineris (Mariner Valley), as seen by the Viking Orbiter 1 on July 22, 1976, was taken at a distance of 19,000 miles (31,000km) from Mars. The camera took three separate pictures — one in red, one in green, and one in violet. The frames were computer processed and matched, and then combined to make the final color image. Areas outside the full overlap show some of the component colors. To the south is Gangis Chasma and the large channel, Shalbatana Vallis, which flows north into the Chryse Basin where Viking landed. Color photographs like this are valuable because they permit delicate searches for mineralogical variations on the Martian surface. Subtle color variations of the type sought occur on this photograph and are being investigated. NASA photographs.

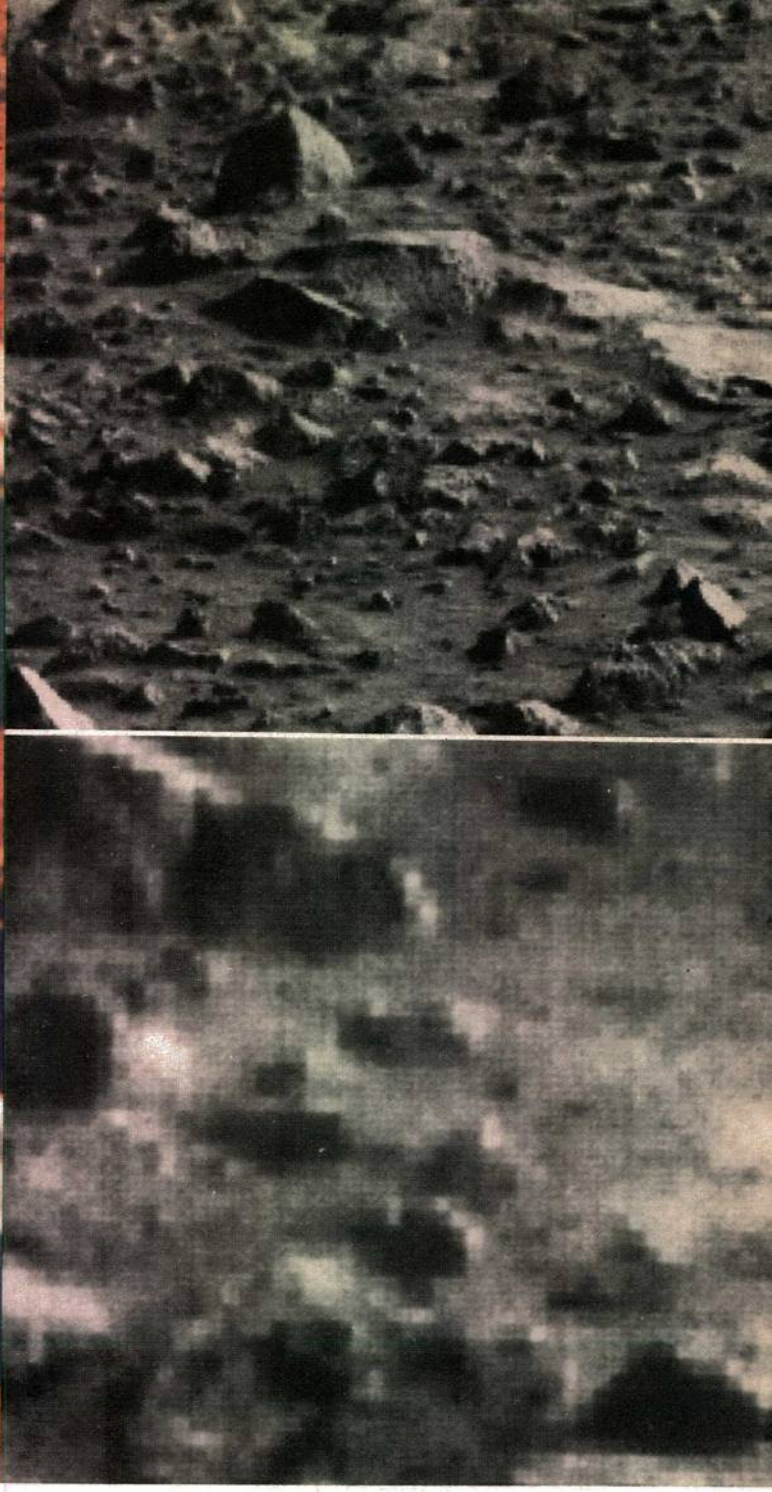




Visible toward the left in this Viking Lander 1 panoramic photograph are trenches dug by the surface sampler arm, seen in the right foreground. The arm and scoop are in the "parked" position, awaiting commands for further sampling activity. The trenches dug by the arm are in a small dune containing fine grained material. Trailing back toward the Lander are signs of material that spilled from the sampler as it picked up the Mars dirt. The brightly colored surface of the planet is strewn with a variety of different sized and shaped rocks of several types. One is the dark, knobby, coarse grained type just to the right of the trenches; another, somewhat more common type includes light colored, irregular, grainy rocks such as the one just above the scoop. Light colored patches lying in the middle distances are outcroppings of bedrock, which also underlies the landing site. Seen on the horizon are large rocks three to six feet (one to two meters) in size, located about 330 feet (100 meters) from the Lander. These blocks may be associated with a crater thought to form the horizon in this direction. The cracked and pitted surface in the foreground was caused by the rocket exhaust of the Lander just before touchdown on July 20, 1976. NASA photograph.

fact, the Lander's eight degree tilt is probably due to a large rock under its "back foot". As with Lander 1, the surface pictures show potential disasters that didn't happen, such as nearby large rocks that could have disabled the craft if it had landed on one.

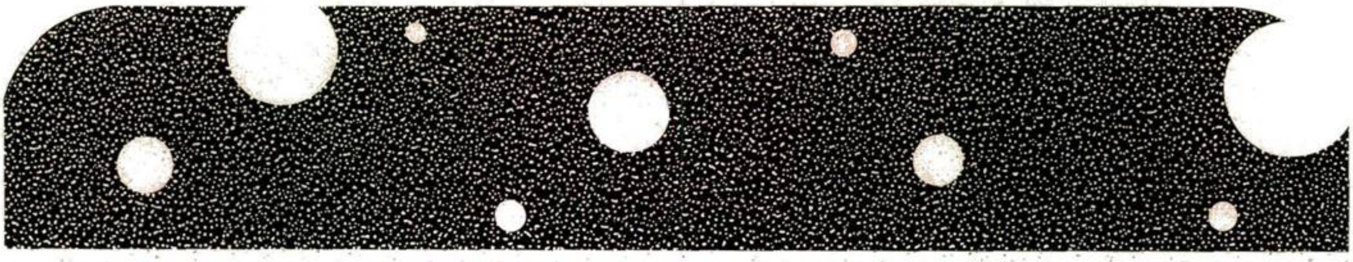
During the Lander 2 phase of the mission, Lander 1 continues to function under the control of its onboard computer, but on a much-reduced schedule, producing 1/10 as much data as previously and communicating this data to Earth via its "direct link". This frees Orbiter 1 to explore the rest of Mars from orbit, returning photographs, infrared, and water vapor data. Greatest interest lies in the polar regions, which may hold the key to a vital question: How much water does Mars have?



Upper right: Viking's cameras are facsimile cameras: Rather than "snap" the whole scene at once, the camera scans the scene with a small moving mirror in vertical lines; as each line is finished, it steps to the next line. When reconstructed on Earth, the resulting picture contains many thousands of little gray boxes called pixels (short for pictorial elements) that blend together to portray the scene. Lower right: When enlarged, the familiar pictorial illusion of continuity breaks apart and we can see individual pixels. NASA photographs.

The discovery made by Viking 2 on Sept. 22 that the north polar cap consists mainly of frozen water contradicted earlier beliefs that the polar regions were composed primarily of frozen carbon dioxide, or "dry ice". Atmospheric scientist Crofton Farmer says the finding of water is "another shred of evidence" that Mars may once have had conditions suitable for life. Great amounts of ice may have been melted by volcanic eruptions early in the planet's history, sending torrents of water across the surface and gouging out the channels and dry river beds that remain today. If water was absorbed into the soil, it may have become bound in permafrost, while water that evaporated into the atmosphere probably condensed at the polar regions.

In order to investigate the north polar region more closely, the rotation of Orbiter 2 was retimed on Sept. 30, tilting the spacecraft's orbit to a 75 degree angle and enabling it to pass over the pole. Communication tests made between Orbiter 1 and Lander 2 ensured that data could be relayed to Earth from the second lander via Orbiter 1. Thus, Lander 1 will be temporarily isolated as the search for water commences.



Black Holes, White Holes and Wormholes

by
John Gribbin

There is nothing new about the idea of black holes. As long ago as 1798, the mathematician Laplace realized that, even within the context of the straightforward Newtonian theory of gravitation, stars might exist from which no light could escape, appearing as black holes in space. The argument is simple: Because of the pull of gravity, anything ejected or launched from a planet, star, moon or other body will escape into space only if it achieves a certain velocity known as *escape velocity*. Anything traveling slower than escape velocity must either fall back into the object or enter a closed orbit, looping around the parent body as a satellite.

This escape velocity increases if the parent body's mass is larger or if its radius is smaller, because the pull of gravity is proportional to mass and inversely proportional to the square of distance. The second of these two possibilities has caused great excitement in the past few years, with the discovery of what may be extremely small, dense black holes. But Laplace realized that if more and more mass were added to a star in space so that its radius increased but its density remained the same, a point must be reached at which the escape velocity is larger than the speed of light — an incredible 186,000 miles (300,000km) per second. A star with the same density as that of our sun, but swelling out to encompass Earth's orbit (93,000,000 miles in radius), would be one of these Laplacian black holes, with even light particles (photons) orbiting the star just as our moon now orbits Earth!

In a recent theoretical model, a massive black hole explains why radio galaxies often appear to have radio sources on either side of them. The black hole (with a mass of one hundred million suns) is surrounded by an accretion disk several hundred astronomical units in diameter, containing a powerful electric field. It causes the ejection of two oppositely-directed, collimated beams of ultra relativistic protons which interact to emit radio waves in enormous clouds outside the galaxy. Artwork by Adolf Schaller.

It's not surprising that Laplace's idea was largely ignored for more than 100 years. After all, there is no reason to believe that a star with the sun's density but a radius of 93,000,000 miles or more could even exist — and if it could, there would be no way for us to detect it because of the black hole effect. It was only in the 20th century, when mathematicians were struggling to come to terms with all the implications of Einstein's General Theory of Relativity, that the idea of black holes appeared again, but this time from the opposite point of view. Instead of adding more material to a star of constant density, a black hole could form by compression of any existing mass — be it a star, planet or teaspoon — to a sufficiently great density.

Escape velocity depends on mass as well as density, and compression is much more easily accomplished by an object of large mass. A small object (like a teaspoon) can easily resist the feeble pull of its own self-gravity. But a large mass has the advantage of its own gravity which will pull the material strongly toward the center, encouraging the compression process.

The gravitational pull of all of Earth on a human being consists of a force of less than 200 pounds. A mass at least three times that of the sun is necessary before self-gravity becomes strong enough to squeeze the matter into a small, dense black hole. This scenario has more immediate excitement than the mundane Laplacian version of black hole formation, especially since we know that stars much more massive than the sun do exist in our galaxy. The bright visible stars with masses 5, 10 or 50 times that of our sun have not become black holes because they are held up by the pressure of the hot material inside — heat coming from nuclear reactions that fuse lighter elements into heavy ones. This nuclear fuel, however, must eventually run out; when it does, these massive stars are likely to collapse into black holes. The only alternative is for them to lose all but a tiny fraction of their mass before the nuclear fires go out. This is a possible solution, but the best way to get rid of a great deal of mass is in a supernova explosion. When a star explodes, the outer layers are blasted into space while the inner core is squeezed into a tiny ball; the result is that the squeeze produced by the blast is enough to compress the core into a black hole anyway. It would seem that very massive stars can't escape their fate. At least some of them must be squeezed behind the curtain of blackness that falls when the escape velocity at their surface exceeds the speed of light.

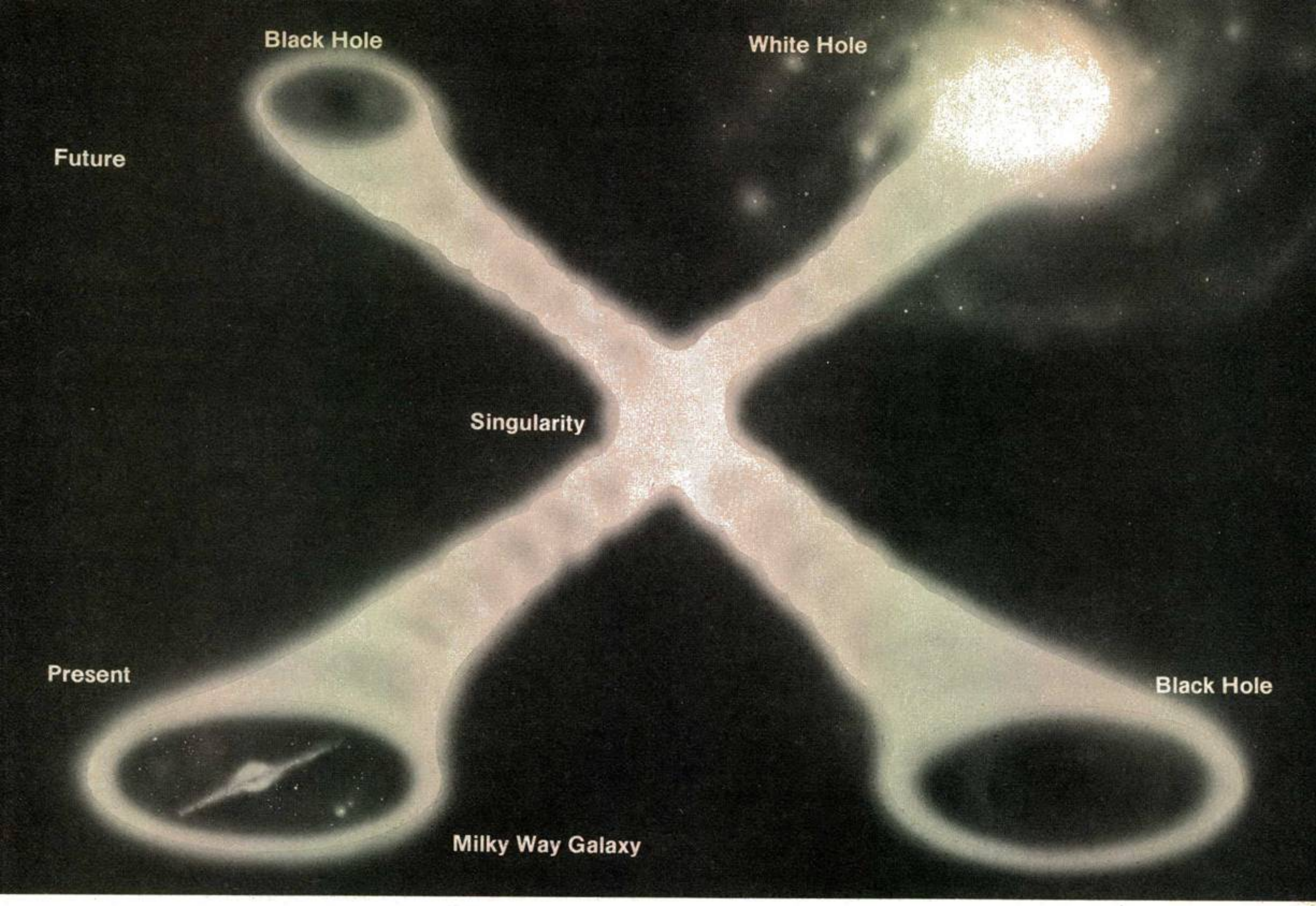
There is a point, however, where relativity goes an important stage further than Newtonian theory — the significance of the black hole collapse for space-time itself. This situation is called a *singularity* — a region where physical theory breaks down. According to the best modern theories, a black hole collapse can continue indefinitely, even beyond the point of invisibility. Matter is crushed ultimately into a mathematical point, and any new matter that falls into the black hole singularity suffers the same fate: It is squeezed out of existence at a point where space and time themselves are squeezed by the intense gravity of the hole. At this stage, physical theory becomes obsolete.

This is why astronomers have been so excited by the discovery of x-ray stars in recent years. Such stars are all very small, and the x-rays seem to come from material falling through their strong gravitational fields (gravitational potential energy being turned into kinetic energy and then radiated away as "heat" at x-ray frequencies). Some of these tiny x-ray stars seem to have more mass than the critical limit necessary to form a black hole of our second type, with the result that black holes are no longer mathematical concepts, but accepted parts of the physical universe. In the past few years, most astrophysicists have dabbled with black holes, either using them to explain away any puzzles in pet theories, or invoking them as the basis of new theories of the universe.

We don't know, of course, what happens to matter that falls into a black hole. Conversely, a key question in astrophysics and cosmology has always been, "Where does all the material in the universe come from?". It's hardly surprising that some people should have tried to answer both questions at once by saying "what goes in must come out", and invoking the opposite of black holes to balance the universe.

This opposite phenomenon has been dubbed *white holes*, for obvious reasons. An even more graphic description would be *cosmic gushers* — sites where fountains of material and energy pour out into the known universe from holes in space. This idea is especially appealing to anyone who has puzzled over the mysteries of quasars, or the outwardly blasting explosions of radio galaxies. Where do they get their energy? Where does the material shot out in these explosions come from? If a dense mass of material locked up inside a black hole (behind that curtain of invisibility) could be triggered into an outward explosion at some stage, it would appear to us as an explosive outburst similar to a quasar or an exploding galaxy.

Such ideas are, to say the least, controversial. One school of thought among students of relativity theory holds that nothing could ever get out from behind the black hole curtain. On the other hand, it is easy to represent the big bang in which the whole universe originated as exactly this kind of white hole explosion from an extremely dense state. We may not know just why a white hole should gush, but then equally we don't know why the universe exploded, although we are sure that it did. Indeed, it's possible to go further and argue in philosophical terms that white holes are more natural than black holes; when we look around our universe we see exploding objects on all sides, in the form of quasars, exploding galaxies (such as Seyferts), and even nova and supernova explosions within galaxies. The whole universe itself is exploding and expanding; what could be more natural than the idea of white holes? Certainly the idea poses many puzzles, but Prof. Jayant Narlikar of Bombay's Tata Institute has likened the situation to the one that existed 10 years ago with respect to black holes. The theory's many unanswered questions did not stop people from working on it and seeking the answers to those questions. Black holes have become respectable, and 10 years of work on white hole theory could make the next



The "tree" and "trouser" models are combined here to represent the theory that black holes (lower right) evolve to white hole (upper right) status. Matter entering the black hole condenses to a point called a singularity where normal physical laws do not apply. This material emerges from a white hole in a time and place completely different from our current position (lower left); it may then not emerge in the same space or time as the Milky Way. Artwork by Mark Paternostro.

decade more exciting — with the additional attraction that this time we can watch the whole development of the idea, forewarned by the example of black holes. These unique areas of relativity theory are no longer of interest solely to a small clique of mathematicians.

So far, the theories about why a white hole should gush are more speculation than anything else. But there are plausible ways of relating black holes and white holes in one theory, and one of the best approaches to this is a model blessed with the title "space-time trousers".

Most people have trouble imagining structures with four or more dimensions, and even professional cosmologists have yet to find a way of drawing four dimensional "models" of the universe (three dimensions for space, one for time) on a two dimensional blackboard. Their standard trick is to use a simplified space-time diagram, in which one direction (usually up the plane of the board or paper) represents the flow of time, while the other (in the plane of the board) represents movement through space. Extending this to represent space by a series of planes at right angles to the drawing surface, and with a little skill in perspective drawing, the three space and one time dimensions can be compressed in an intelligible way into two space and one time dimension in the "model", drawn within the limits of a two-dimensional surface.

The easy way to represent the universe in this picture is like the trunk of a tree. We are somewhere in the middle of the trunk (which may not have any "edges" in some theories); the flow of time is equivalent to moving upward through the trunk. Things begin to get interesting when you imagine what happens if the trunk forks. Suppose we were located in galaxy A, next door to another galaxy B, each moving upward as time passes until the fork is reached. If each galaxy moves into a separate branch of the tree at this time, it would seem to us that galaxy B had disappeared — fallen into a black hole and become invisible as far as the known universe of our branch was concerned.

Repeated branching of the space-time tree is equivalent to the pessimistic view some cosmologists have of the ultimate fate of the universe — everything eventually being gobbled up in a series of black holes. But there is no real need for this pessimism.

With just one fork on the space-time model, the picture looks like a fat letter "Y", which gives the model its name. But suppose we could run the whole thing in reverse — or, which is the same thing, turn the picture upside down. Now, the two branches of the "Y space-time" become the legs of a pair of trousers, merging into a pseudowaist. The journey of galaxy A up the leg of the trousers brings it to a spectacular moment of time when all the material in the neighboring branch of space-time — in the other leg of the trousers — suddenly pops into view!

The analogy of this simple model with quasars or Seyferts is far from exact; we don't see (or haven't yet seen) whole galaxies popping into view complete and intact. But if we make the other leg of the trousers very thin, or at least restrict its width where it joins the waist, we can imagine matter fountaining into the visible universe in a more energetic fashion.

Perhaps an even better analogy is the view of the mainstream of space-time, our visible universe, as a broad onward flowing river joined by many rushing streams that plummet downward from surrounding mountains. In both models, new material has, in effect, been created in our universe. And although these analogies are only poor representations of the detailed reality of the mathematical description of the universe in relativistic terms, the physical intuition provided by the simple pictures is a fair representation of the implications of the mathematics in broad outline.

We could stretch the analogy further by relating the big bang creation of the universe to the source of our space-time river in some great spring — but perhaps we shouldn't belabor the point. More important, within the framework of relativity theory is the possibility of envisaging even more complex situations than the simple model of the "trouser space-time". Imagine branches both joining and leaving the mainstream of space-time, and matter flowing into and out of the visible universe through these holes in space.

Still resting on a secure mathematical foundation, this branching model can be extended until it represents not so much a simple branching tree, but the complex interconnected root system of some exotic trees and other plants, where roots and branches do not simply fan out from a single core but are joined and rejoined to one another — multiconnected.

In the same system, we have aspects of both the branching "Y" space-time and the joining of space-time trousers. Matter can both appear from white holes and disappear into black holes, and the same material can disappear into a black hole in one part of space-time and reappear from a white hole somewhere (and sometime) else. For all practical purposes, such material has tunneled through a "wormhole" in the fabric of space-time — a region where the laws of physics as we know them do not apply, and where time, perhaps, does not even flow.

In a multiconnected universe, the question of why a white hole gushes is simply answered, "Because something fell into a black hole somewhere else at some other time." The whole system resembles Gruyere cheese, in which the holes represent the multiconnected universe in which we probably live, and the cheese itself represents — what? No one knows for sure, although avid science fiction readers may already have noted the similarities between this kind of structure and the "hyperspace" often mentioned by science fiction writers.

As long ago as 1962, when John Wheeler's **Geometrodynamics** was published, this kind of hyperspace was respectable science fact. The fabric through which our universe tunnels in a multiconnected way is described by Wheeler and others as a structure of curved empty space, in which "before" and "after" have no meaning. If a traveler could be sent into hyperspace and back out into another of the tunnels that make up the "real" universe, no time would have elapsed for him, even though he might emerge many light-years away.

Apart from the awesome problems of trying to get into hyperspace in the first place, it might be rather difficult to decide "when" and "where" to emerge again. A better prospect might be to find a natural wormhole providing a shortcut across one of the bends on the tunnel of space-time in which we live. That, however, would involve diving into a black hole; apart from any other considerations (such as the prospect of being crushed by intense gravity), this would very definitely be a one-way system of travel. To get home again, our intrepid traveler would need a convenient black hole/wormhole/white hole system running in the opposite direction through space-time.

The prospects don't look good. Using hyperspace or wormholes for travel seems likely to remain science fiction for a very long time to come, even though the existence of hyperspace and wormholes is now discussed within the framework of factual science. But it does look as if we can see, in general terms, just what happens when matter falls into black holes, and it is a very satisfactory and tidy situation for astrophysics to be able to associate the disappearance of matter in this way with the emergence of matter at other energetic sites in the universe. No one knows for sure that this model of black and white holes linked by wormholes is definitely correct; indeed, some theorists find the concept abhorrent. But, in a pleasingly symmetrical fashion, it is an explanation of two of the most taxing problems of modern astronomy.

---

*Dr. John Gribbin, former assistant editor of **Nature,** works at the Science Policy Research Unit, University of Sussex. He is the author of **Our Changing Universe,** published this fall by Dutton & Co., and of **White Holes,** to be published early in 1977 by Delacorte Press.*

Announcing

BIG EAR

by

John Kraus

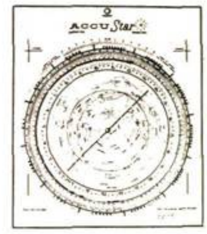
Director and Founder
Ohio State-Ohio Wesleyan
Radio Observatory
Author — RADIO ASTRONOMY

- **BIG EAR is a new book by a pioneer radio astronomer, inventor of antennas, designer and builder of radio telescopes and mapper of the Cosmos.**
- **BIG EAR is about the Ohio telescope, how it has probed the Universe to its limits and now searches for intelligent life beyond Mars.**
- **Accounts of personal exploits leading up to these exciting activities provide revealing behind-the-scenes glimpses.**
- **An authoritative book written in a warm, entertaining, non-technical style.**

225 pages, illustrated
Published July 1976

Paperbound $3.25, hardbound
$6.25, postpaid
Cygnus-Quasar Books, Box 85,
Powell, Ohio 43065

ACCU Star



SIDEREAL TIME
ANYPLACE — INSTANTLY — ACCURATELY

- Whether you are a begining or advanced astronomer, to find any object in the sky, you must convert your local time to sidereal time units.
- Accustar does it quickly without paper and pencil. Accustar teaches you how to use your telescope's setting circles. Accustar is used by observatories, universities, and astronomers throughout the world.
- Each Accustar package contains: The basic Accustar instrument with star chart, Sky Finder overlay, and the Accustar 90 page text. Order yours today! $11.95 ppd.

OBSERVATION BINOCULARS

These are some of the finest large aperture binoculars we have ever seen! 20 power with 80mm. objectives. American type frames. Erfle eyepieces. Over 17 inches long. Built - in sliding tripod adapter. Fully coated lenses with luggage type carrying case with lock.

20x80 BLCF ———— $232.00 ppd.

NEW

BINOCULARS FOR DEEP SKY OBSERVATION

We are now carrying a number of large binoculars of special interest to astronomers. All models have fully coated optics, center focus design, and come complete with a nice quality carrying case. The 11 power model has a 4.5 degree field and the 10 power model a 5 degree field. These models represent the ultimate in rich-field viewing.

8x56 RCF	$ 99.95 ppd.
10x70 ZCF	$110.00 ppd.
11x80 ZCF	$129.00 ppd.
20x80 ZCF	$129.00 ppd.

GET FREE CATALOG NOW

Send for our complete catalogue of telescope parts, eyepieces, mirror kits, finders, focusing mounts, books, and accessories. It is yours for the asking.

"AN OLD AND EXPERIENCED SUPPLIER TO THE TELESCOPE FIELD"

University Optics, Inc. 2122 East Delhi Road
Ann Arbor, Mich. 48106
free catalog

ASTRONOMY: BLACK HOLES TO QUASARS

Produced only after extensive consultation with noted astronomers, this is the first comprehensive and complete coverage of astronomy specifically intended for those who want to enjoy the best in color astrophotography from the major observatories of the world combined with up-to-the-minute data on every phase of astronomy, presented in an easy-to-understand way. This set has it all, including the sun, moon, planets, asteroids, comets, meteors, stars (pulsars, novae, supernovae, variable, multiple), star clusters, Milky Way, nebulae, galaxies, galaxy clusters, black holes, quasars, etc. Enjoy the optional tape cassette recording which contains the detailed narration along with relaxing classical mood music and is keyed to the 40 color slides. All slides are 35mm in 2" x 2" mounts. The entire package is attractively gift boxed in plastic. USA orders send $.75 extra for postage. All foreign orders 20% extra. Calif. orders 6% extra for sales tax.

40 Color Slides	*$15*
Tape Cassette Recording	*$ 6*

UNIVERSAL SCIENTIFIC CO.
A Subsidiary of Universal Film Productions
4846 Aliano Plaza
Yorba Linda, California 92686
telephone 714-996-8862

GAZER'S GAZETTE

Doubles, Binaries and Multiple Stars

by
Henry J. Phillips

Certain categories of celestial objects are frequently neglected by the potential observer. The moon, for example, is often disregarded by all except diehard lunar observers or rank neophytes with their first telescopes. We also tend to forget about most of the nebulae and clusters that are *not* included on Messier's list. Even more frequently ignored are double or multiple star systems.

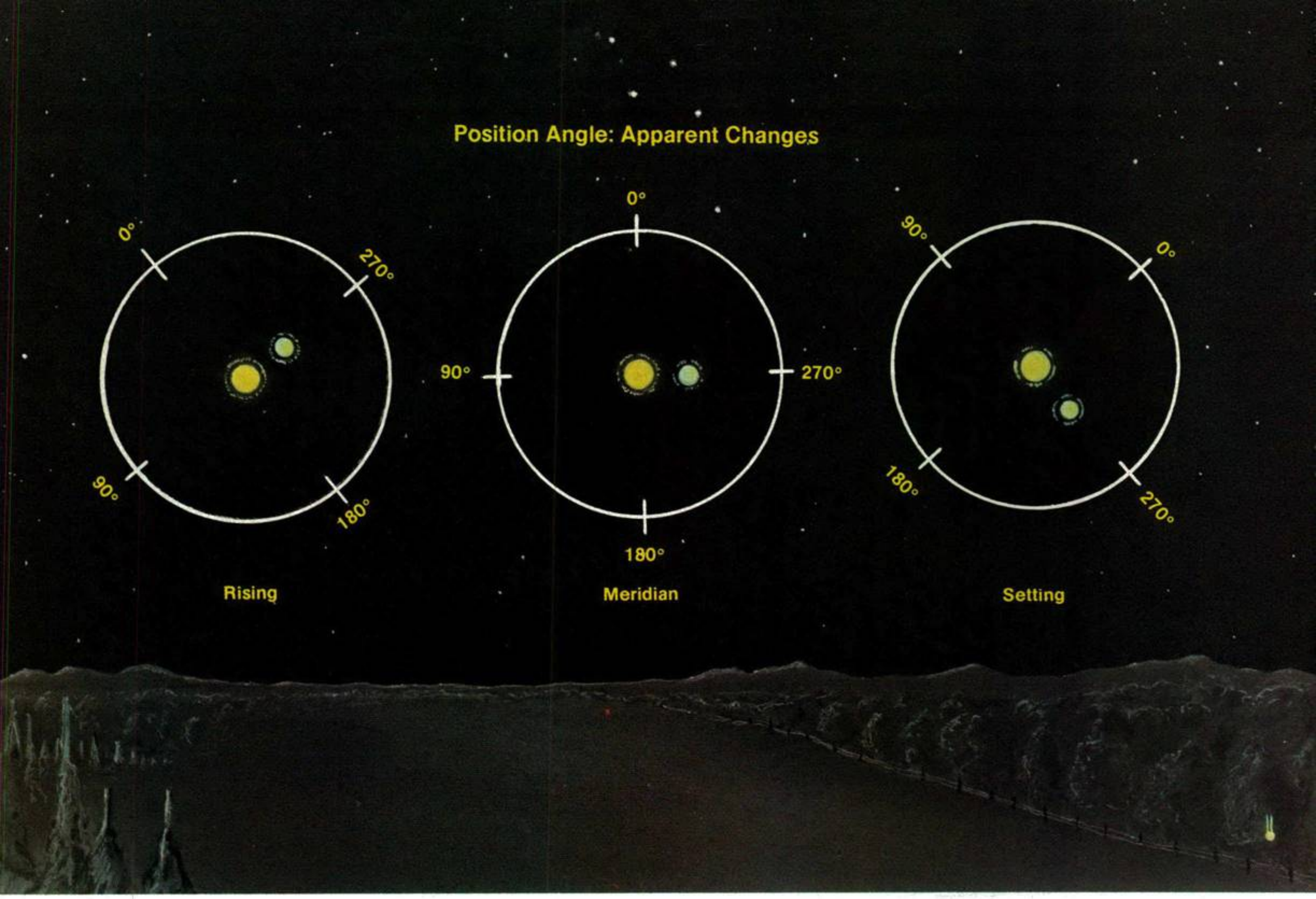
There are, of course, a few showpieces (usually demonstrated at star parties to nonenthusiasts) that everyone knows about, including Albireo, Mizar, and Epsilon (ϵ) Lyrae — the "double double". But how many people ever bother to take a look at Eta (η) Cassiopeiae — a beautiful yellow/purple color contrast? Or how about Zeta (ζ) Aquarii, a fine separation test with two stars of almost equal brightness and color? How many observers are aware that of the 21 first magnitude stars in our sky, 12 are double — with most of these 12 especially attractive because of their ready availability or the challenge they present?

In short, doubles have a good reputation, but receive little actual observation. This is unfortunate, because doubles provide not only an attractive subject, but also a good test of your telescope's limits. Splitting double stars will let you know exactly how much you can expect of your telescope and its performance. And when you're ready to move up to a larger optical system, doubles are the most convenient and possibly most accurate test of its capabilities. Finally, patient observers can find in double stars the longest-term study projects available to them — even more so than long-period variable watching. Over a period of years, you can actually watch the components of a binary system change their respective positions as they orbit one another!

These are especially important observations for nonprofessionals to make and keep careful records of. Until the end of the 19th century, doubles were probably the most closely and carefully studied objects in the heavens — at least by amateur astronomers. Advances in cosmology, however, were soon to reveal the true nature of many so-called nebulae as the incredibly distant galaxies we know today. As a result, these objects took on a fresh glamor, and small telescope owners eagerly turned their instruments toward these objects, often to the exclusion of all else. In addition, planetary study went through a renaissance at about the same period, and these objects received fresh attention from amateurs.

Consequently, many doubles that had once received careful study and measurement have been unnoticed for many years. As both major observatories and active amateurs turned to other objects, doubles fell into a comparative neglect from which

It is estimated that anywhere from 1/4 to 1/2 of all the stars in the Milky Way are members of binary or multiple systems. This view from inside the Epsilon Lyrae system — the famed "double double" — shows Epsilon^1 A in the foreground. Its companion, appearing 650 times as bright as the full moon, revolves at a distance of about 200 astronomical units, while the more distant components of Epsilon^2 outshine all the other stars in this sky. Artwork by Mark Paternostro.



Novice astronomers are frequently confused when a double star, upon rising or setting, appears to exhibit a different position angle than that given in charts or tables. Confusion ends when we remember that constellations and stars are oriented differently upon rising or setting than when crossing the south point or meridian, from which position angles are measured. Depicted here are the apparent changes in the angle of Gamma Delphini as viewed through a telescope equipped with a star diagonal. Artwork by Mark Paternostro.

they still have not recovered. (A similar situation exists with regard to variable stars; there are cases on record of variables that have received no known observations in almost 50 years!)

Doubles are sometimes dismissed as "boring" or "dull", but they actually come in as many different varieties as do types of galaxies. Most doubles belong to *binary systems*, in which the two stars travel together through space. The stars in binaries usually exhibit orbital motion; if they don't they form what is known as a *fixed binary*. There are also a few *optical doubles* — fairly rare cases where two stars appear to lie close together, but actually do not. They lie along a single line of sight as seen from Earth's vantage point, but in fact may be separated by light-years of space. The odds against such an alignment are high, but there are so many stars that optical doubles inevitably crop up here and there. In either case, the brightest member of a double is referred to as the *primary*, or as *A*. The other star (or stars, if the system is multiple) is called the *companion*, the *comes* (plural comites), or *B*. In a multiple system, the dimmer the stars get, the further down the alphabet you go to name them.

There are three important measurements to consider in any study of double stars. The first, as you might expect, is the star's magnitude. It is the exception rather than the rule for both members of a double star system to have the same brightness; usually one is obviously brighter than the other. The brighter the primary, the more difficult it becomes to see the companion star. The problem is compounded if the companion lies very close to the primary; in such cases, it's sometimes extremely hard to detect a companion even in telescopes of 12 inches aperture. Sirius, described below, is a good example of this type of binary.

The *combined magnitude* of a double is often found in star lists. Naturally, if a companion is not too much dimmer than its primary, its light will make the star appear brighter to the naked eye than can be accounted for by the primary's light alone. The combined magnitude of Alpha (α) Centauri, for example, is +0.06, ranking it third in brightness of all naked eye stars. Alpha's two component stars, however, shine at magnitudes +0.33 and 1.70; if the magnitude of the primary alone were the criterion for judging stellar brightness, Alpha Centauri would fall to seventh place.

The second important measurement is *separa-*

tion. Obviously, for two stars to be considered components of a double system, they must be close together. Doubles can be separated by anywhere from 12 minutes of arc (as with Mizar), down to the limit of resolution in the world's largest telescopes. The usual separation is between about 60 seconds of arc down to a fraction of one. The closer two stars lie together, the more difficult they are to separate in the telescope.

A useful guide for finding the minimum resolving power of your instrument is *Dawes' limit.* Divide the aperture of your telescope (in inches) into 4.56; the result will be the angular resolution your telescope is capable of. For example, if you have a 2.4 inch refractor, you can split doubles down to those that are separated by 1.9 seconds of arc. A six inch reflector will split doubles of 0.76 seconds separation, while a 12 inch can go as far down as 0.38.

Dawes' limit, while handy, is not entirely accurate. It works for stars of identical brightness; if the two stars in a double lying at your telescope's maximum resolving power have widely different magnitudes, you probably won't be able to see the fainter of the two. In addition, since most of the starlight visible through any kind of optical system appears to be spread out over a tiny disk called the Airy disk (see "Star-Test Your Telescope", October 1976), you may not be able to split very close doubles because their disks run into one another. Atmospheric conditions will play their part too. If you can split doubles that are separated by twice Dawes' limit for your instrument, you're doing fine.

Potentially the most interesting of the three measurements is the *position angle* (P.A.). This is the inclination, measured from the north point eastward, of a companion star to the hour circle on which its primary is located. In other words, if a companion is due north of the primary, its P.A. is 0 degrees; if it is due east, 90 degrees; due south, 180 degrees, and due west, 270 degrees. Stars may be located anywhere between these compass points, and if you know a star's position angle, you know on which side of its primary it lies — a useful figure for very close doubles or for those with wide magnitude differences. Observers must exercise care in the use of this measurement, however, for a position angle is measured by the star's appearance as it crosses the meridian. If you're looking at a double just rising above the horizon, the apparent position angle will be different because of the star's tilt. This can confuse you if you're not aware of the criteria for measurement.

So what makes this measurement so interesting? Simply that a binary's P.A. can slowly change over the years as the stars orbit one another. Some binaries appear to be fixed and their position angles don't change, while others crawl through their orbits, changing P.A. by one degree per decade. But many binaries exhibit obvious changes as a companion star zips around its primary. A double star's period is the time it takes for the companion to return to its original P.A.; if a double has a period of less than about 60 years, such motion is obvious over a period of a few years. Therefore, be careful when you consult an atlas or chart for a binary's P.A. — it may have changed since the book was published.

Now that we know *how* to look, the beginner will naturally want to know *what* to look for. Lists of double stars can be found in any good atlas; we'll just describe a few of the best places to start.

Let's begin with a few of those showpieces we mentioned earlier. The most famous double star in the sky is, of course, Mizar (officially known as Zeta Ursae Majoris), the middle star in the handle of the Big Dipper. Before the invention of the telescope, Mizar was one of the few doubles to have both a separation wide enough and a companion bright enough to be seen with the naked eye. The

1st Magnitude Double Stars

Star	Combined Mag.	Components Mags.	Period	P.A. (1976)	Sep.
Sirius	-1.37	-1.37,8.7	49.9 years	57°	11.1"
Alpha Centauri	+0.06	+0.33, 1.7	80.1 years	167°	18.0"
Rigel	+0.34	+0.34, 7.0	fixed	206°	9.2"
Capella	+0.21	+0.89, 1.04 sp	102 days	—	—
Procyon	+0.48	+0.48, 9.5	40.2 years	283°	4.0"
Beta Centauri	+0.86	+0.9, 9.0	unknown	255°	1.4"
Aldebaran	+1.06	+1.06, 11.0	unknown	112°	31.4"
Acrux	+1.05	+1.58, 2.09	unknown	114°	4.7"
Betelgeuse	+0.4-1.3	+0.4-1.3, sp	5.78 years	—	—
Antares	+1.22	+1.22, 6.5	853 years	274°	2.9"
Spica	+1.21	+1.21, sp	4.01 days	—	—
Regulus	+1.34	+1.34, 7.64	fixed	307°	176.5"

A blank in the last two columns indicates the components cannot be separated except spectroscopically; sp = spectroscopic binary.

63 Double Stars

			Magnitudes				
Star	**R.A.**	**Dec.**	**Combined**	**Components**	**P.A.**	**Sep.**	**Comments**
η Cassiopeiae	0^h46^m	+57°33'	3.61	3.64,7.5	307°	10.1"	yellow,purple
α Ursae Minoris	1^h48^m	+89°02'	2.12	2.12,9.0	217°	18.3"	Polaris; optical pair
γ Arietis	1^h50^m	+19°03'	4.0	4.75,4.83	359°	8.2"	both white
α Piscium	1^h59^m	+02°31'	3.94	4.33,5.23	308°	2.1"	both white
γ Andromedae	2^h00^m	+42°06'	2.21	2.28,5.08	63°	10.0"	yellow,blue;B double
ι Cassiopeiae	2^h24^m	+67°11'	4.56	4.7,7.0,8.2	247°,116°	2.3" 7.2"	yellow,blue,blue
γ Ceti	2^h40^m	+03°02'	3.58	3.7,6.4	293°	3.0"	
η Persei	2^h47^m	+55°41'	3.91	3.93,8.6	301°	28.4"	
θ Eridani	2^h56^m	-40°30'	3.06	3.42,4.42	88°	8.5"	both white
32 Eridani	3^h51^m	-03°06'	4.68	4.95,6.33	348°	6.7"	yellow,aqua
η Orionis	5^h22^m	-02°26'	3.44	3.7,5.1	83°	1.5"	both white
δ Orionis	5^h29^m	-00°20'	2.46	2.48,6.87	0°	52.8"	
λ Orionis	5^h32^m	+09°54'	3.49	3.66,5.56	42°	44.0"	both white
σ Orionis	5^h36^m	-02°38'	3.65	3.9,6.5,7.2	85°,61°	12.8",41.6"	A has close *comes*
ζ Orionis	5^h38^m	-01°58'	1.91	2.05,4.21	164°	2.4"	both bluish
γ Leporis	5^h42^m	-22°28'	3.61	3.8,6.41	351°	94.9"	
θ Aurigae	5^h56^m	+37°13'	2.70	2.71,7.5	320°	3.0"	
β Monocerotis	6^h26^m	-07°00'	3.93	4.7,5.2,5.6	132°,108°	7.4",2.8"	triple,all yellow
12 Lyncis	6^h41^m	+59°30'	4.85	5.4,6,8.5	100°,309°	1.8",8.5"	triple
δ Geminorum	7^h17^m	+22°05'	3.5	3.51,8.1	211°	6.8"	yellow,reddish
α Geminorum	7^h31^m	+32°00'	1.58	1.9,2.9,9.5	186°,165°	2.2",73.4"	Castor
κ Puppis	7^h36^m	-26°41'	3.81	4.5,4.62	318°	9.8"	both white
ζ Cancri	8^h09^m	+17°48'	4.71	5.7,6;6.3,7.8	95°	5.9"	2 binaries; all yellow
ι^2 Cancri	8^h43^m	+28°57'	4.09	4.2,6.6	307°	30.7"	orange, blue
ε Hydrae	8^h44^m	+06°36'	3.43	3.48,6.9	269°	2.9"	A double again
38 Lyncis	9^h15^m	+37°01'	3.82	4.0,6.0	231°	2.9"	
γ Leonis	10^h17^m	+20°06'	2.3	2.61,3.8	132°	4.3"	both yellow
ξ Ursae Majoris	11^h15^m	+31°49'	3.88	4.4,4.8	109°	2.5"	both white
δ Corvi	12^h27^m	-16°14'	3.1	3.11,8.4	212°	24.2"	white, lilac
24 Comae Berenices	12^h32^m	+18°39'	4.96	5.18,6.72	271°	20.3"	orange,aqua
γ Virginis	12^h39^m	-01°11'	2.91	3.6,3.63	309°	5.2"	both white
α Canum Venaticorum	12^h53^m	+38°35'	2.8	2.9,5.39	228°	19.7"	Cor Caroli; both blue
ζ / g Ursae Majoris	13^h21^m	+55°11'	—	2.17,4.02	80°	12'	Mizar/ Alcor
ζ Ursae Majoris	13^h21^m	+55°11'	2.17	2.4,3.96	150°	14.5"	Mizar;both white
ζ Bootis	14^h38^m	+13°57'	3.86	4.6,4.6	313°	1.2"	
ε Bootis	14^h42^m	+27°17'	2.59	2.7,5.12	338°	2.9"	yellow,blue
ξ Bootis	14^h49^m	+19°18'	4.64	4.8,6.9	307°	6.7"	yellow,red
μ Bootis	15^h22^m	+37°33'	4.33	4.5;7.2,7.8	171°,25°	108.8",2"	triple
δ Serpentis	15^h32^m	+10°42'	3.85	4.23,5.16	179°	3.7"	both white
ζ Coronae Borealis	15^h37^m	+36°48'	4.69	5.07,6.0	305°	6.3"	blue,green
η Lupi	15^h56^m	-38°15'	3.61	3.64,7.7	21°	15.2"	
ξ Scorpii	16^h01^m	-11°14'	4.1	4.16,7.2	54°	7.9"	A double again
β Scorpii	16^h02^m	-19°40'	2.76	2.9,5.06	23°	13.7"	both bluish;A double
ν Scorpii	16^h09^m	-19°20'	4.16	4.4,6.4;6.8,7.8	337°	41.4"	2 orbiting binaries
16/ 17 Draconis	16^h35^m	+53°01'	4.65	5.64;5.6,6.6	194°,111°	90.6",3.5"	triple
α Herculis	17^h12^m	+14°27'	3-4	3-4,5.39	109°	4.6"	orange, aqua; A variable
δ Herculis	17^h13^m	+24°54'	3.15	3.16,8.8	216°	10.0"	white, purple
ρ Herculis	17^h22^m	+37°11'	4.14	4.52,5.47	317°	4.0"	
ν Draconis	17^h31^m	+55°13'	4.2	4.95,4.98	312°	62.0"	both white
95 Herculis	17^h59^m	+21°36'	4.42	5.21,5.13	258°	6.5"	red, green
70 Ophiuchi	18^h02^m	+02°31'	4.07	4.27,6.0	87°	2.1"	yellow, red
ε Lyrae	18^h42^m	+39°37'	3.83	5.06,6; 5.15,5.37	172°	207.8"	Double Double; all white
β Lyrae	18^h43^m	+37°32'	4.06	4.29,5.87	150°	43.7"	
ζ Lyrae	18^h48^m	+33°18'	3.4-4.3	3.4-4.3,7.8	149°	46.6"	A eclipsing binary
θ Serpentis	18^h53^m	+04°08'	4.1	4.5,5.37	103°	22.6"	both white
β Cygni	19^h28^m	+27°52'	3.1	3.24,5.36	55°	34.6"	Albireo;orange,blue
δ Cygni	19^h43^m	+45°00'	2.97	3.0,6.5	246°	2.1"	white,bluish
ε Draconis	19^h48^m	+70°08'	3.9	4.0,7.1	12°	3.3"	
$\alpha^{1,2}$Capricorni	20^h13^m	-12°41'	—	4.5,9;3.7,10.6	291°	6'16"	1 optical; 2 binary
γ Delphini	20^h44^m	+15°57'	4.12	4.49,5.47	269°	10.4"	yellow,green
61 Cygni	21^h04^m	+38°30'	5.12	5.54,6.35	152°	27.0	both orange
β Cephei	21^h28^m	+70°20'	3.32	3.32,8.0	250°	13.7"	both bluish
ζ Aquarii	22^h26^m	-00°17'	3.75	4.42,4.59	260°	2.0"	both white
δ Cephei	22^h27^m	+58°10'	4.1-5.2	4-5,7.5	192°	41.0"	orange, blue; A Cepheid variable

companion even acquired its own name: Alcor. Mizar's magnitude is 2.17, while Alcor's is 4.02; the two stars are separated by 12 minutes of arc.

All this would be sufficient to make Mizar one of the sky's finest doubles, but the system's beauty is enhanced when we turn our telescopes on the pair and discover that Mizar is itself double! This second companion, lying at a P.A. of 150 degrees, is separated from Mizar by 14.5 seconds of arc. In turn, each of these three stars (Mizar A and B, and Alcor) are *spectroscopic binaries* — that is, their companions lie so close that they cannot be detected visually, but only through the spectroscope. Mizar is thus a sextuple system, worth investigation any night in the year. All three stars appear blue-white through the telescope, as all are of spectral class A.

If Mizar is the sky's best known double, the runner-up is undoubtedly Albireo [Beta (β) Cygni]. This beautiful pair of stars, separated by 34.6 seconds of arc, is perhaps the best example of a color contrasting double — a system in which the stars have obviously different colors. Albireo A (magnitude 3.24) has a bright gold color, while B (magnitude 5.36) is a deep, beautiful blue. The two stars are fixed in their positions, and the blue companion lies at a P.A. of 55 degrees. To the naked eye, the two stars shine with a combined magnitude of 3.10. Another famous color contrasting double is Gamma (γ) Andromedae. The stars in this system have colors similar to those found in Albireo, but they are closer together, having a separation of only 10 seconds of arc. In addition, the fifth magnitude blue companion is actually a pair of blue stars (B and C) lying extremely close together; their maximum separation is only 0.6 seconds of arc — a challenge even for those equipped with larger instruments. The orbits of B and C makes this separation even smaller at times, and the two become almost impossible to resolve.

Some doubles, on closer investigation, turn out to have more than just two stars and are therefore referred to as *multiple star systems*. The finest example in this category is Epsilon Lyrae, the famed "double double". Obviously double to the naked eye, both components are revealed as close binaries when viewed through a telescope at a magnification of about 150. The binaries, lying 208 seconds of arc apart, having separation of 2.9 and 2.3 seconds; all four stars are fifth or sixth magnitude, and all are white. Another beautiful multiple system is the triple Iota (ι) Cassiopeiae. Iota is a multiple and a color contrast all in one: The yellow primary (magnitude 4.2) has bluish companions with magnitudes of 7.1 (separation 2.4 seconds, P.A. 251 degrees) and 8.1 (separation 7.4 seconds, P.A. 113 degrees).

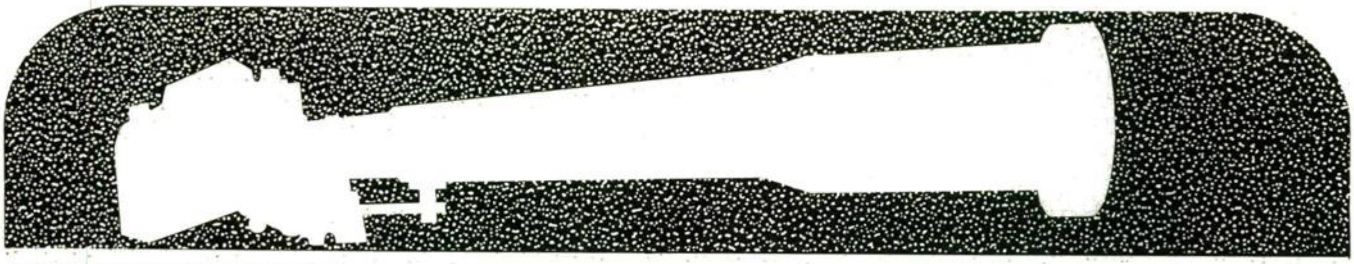
One more well-known double is Gamma Virginis. A pair of white stars of almost equal magnitude, Gamma is best known for its obvious orbital motion. The two stars have a period of 180 years, and one of the stars is gradually changing its P.A. as it creeps up on its neighbor. The binary's maximum separation is six seconds of arc, while at minimum, the two stars are separated by only 0.4 second. Because of our viewing angle, the companion changes its P.A. much more rapidly at periastron than apastron. The patient viewer will be well rewarded by continuous observation of Gamma through the years — truly a lifetime project!

What about those first magnitude doubles we mentioned earlier? The most famous of them is Sirius, the brightest star of all. Sirius' companion was the first discovered white dwarf star; about as large as the planet Uranus, Sirius B has a mass almost as great as that of our sun. Although Sirius A and B are currently near their maximum separation, it is almost impossible to see the dwarf star unless you have a telescope larger than eight inches; even then you'll need high power. The reason for this is, of course, the intense glare from Sirius itself, which all but swallows up what feeble light the companion can produce. (Sirius A is 2,500 times as bright as Sirius B.) But the view is well worth the effort made to see the pair.

Among the other members of the "brightest double" family are Rigel and Antares. Rigel, not being as bright as Sirius, doesn't outglare its companion quite as badly — although the dimmer star is admittedly difficult to detect. The two can be barely separated in a three inch telescope, while larger instruments provide a much nicer view. Antares, the red supergiant of Scorpius, has a small emerald green companion only three seconds of arc away. The two are best seen through telescopes of 10 inches aperture or larger.

Further information on the first magnitude doubles is contained in the table on page 31 . Unhappily, the most spectacular members of this somewhat arbitrary class (Alpha Centauri and Alpha Crucis) are invisible from midnorthern latitudes. Other particularly interesting doubles are listed in the table on page 32. This list is intended only as a starting point — there are simply so many doubles that it's impossible to list them all.

Observation of doubles is both profitable and pleasing. For some reason, the sight of two stars lying very close together is an extremely satisfying one, whether the stars are similar or different in color or magnitude, and whether they are widely or narrowly separated. Clearly, there is no need for doubles to remain embedded in neglect. Observation of galaxies may be emotionally fulfilling, but it does not provide the scope for worthwhile — even necessary — study that doubles present. The major observatories, with so many projects in hand, simply have no time available to watch the slow changes in separation and P.A. that tell us so much about binaries. This is where the amateur can make a real contribution; it may possibly be time for owners of small instruments to re-examine their priorities.



PHOTOGRAPHY IN ASTRONOMY

Astrographic Cameras

by
Richard Berry

Two decades ago, astrophotography was dominated by astrographic cameras (constructed with World War II surplus lenses) and Newtonian reflectors. Today, with the improved quality of 35mm cameras, color films, and the commercial availability of Schmidt cameras, astrographic cameras have become uncommon — yet the increased availability of low reciprocity failure spectroscopic emulsions has made them potentially far more valuable now than they ever were!

Astrographic cameras avoid the grainy dilemma of small film formats by using a large film or glass plate with a long focal length lens, covering a large portion of the sky. In fact, with a focal length of 600mm, a typical astrographic camera may photograph 10 to 50 times more sky than a 35mm camera with a telephoto lens of the same focal length! Of course, 35mm cameras are perfectly suited for many of the tasks astrophotographers ask of them. But the combination of grainless prints, large image scale, and field of view are the province of the astrographic camera.

If you're just starting to venture beyond the realm of 35mm astrophotography, you may find that an astrographic camera — whether homemade at low cost, or purchased from one of several world renowned firms — is just the thing for you. An experienced astrophotographer might want to produce some mural-quality survey photographs of the Milky Way that a Newtonian or Cassegrain type telescope simply cannot provide. An astrographic camera is the answer.

Astrographs may use any size film or plate, but the most common is 4 x 5 inches. Your first question, of course, may be: Don't those big films cost a lot of money? A box of 25 sheets of Royal-X Pan or Royal Pan sheet film sells for around $7; but since each single sheet of film should yield a negative worth keeping, that's not a bad price. (It's the same as only 10 Polaroid color shots.) Of course, the best results come from using Kodak's spectroscopic emulsions coated on thin sheets of glass. A box of 36 plates (4 x 5 inches) costs about $55 (or the cost of two Polaroid shots per plate). The resultant picture will really be worth having: It will record perhaps a half million stars and an intricacy of detail never reached with small-format cameras.

What of the astrograph itself — where can you get them? — what do they cost? — how do you use them? The answers are so diverse and varying that no single answer applies; it will depend largely on what you want, what you can find, and how much work you can do yourself — as well as what you can afford.

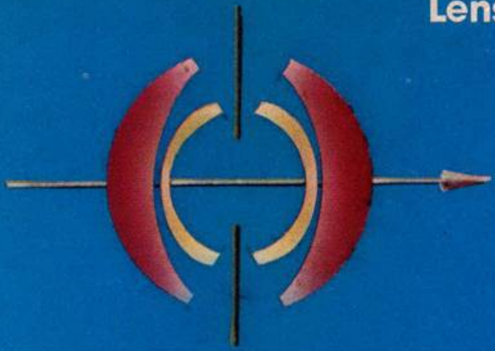
Surplus Optics

During World War II, the United States manufactured tens of thousands of high quality large aperture lenses for use in aerial reconnaissance and mapping. After the war, many of the lenses were sold as surplus at very low prices — as low as $15 for lenses originally worth thousands of dollars.

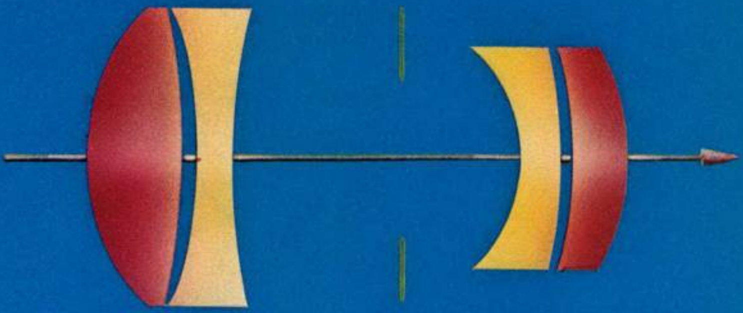
Today, surplus lenses are relatively rare and therefore more expensive. You can often obtain one from someone who bought it when it was cheap, but never got around to building an astrographic camera with it. Several companies, notably C & H Sales Co., 2174 East Colorado St., Pasadena, Calif. 91107, still offer a variety of aerial lenses. Often your local surplus or Army/Navy dealer will have a few odd lenses on hand at good prices. You'll have to look around a bit, but they *are* available.

In buying aerial lenses, you'll have to remember that they were designed for use as aerial cameras, and are therefore not optimum star cameras — only a good compromise. Aerial photographs were almost always made using a yellow or red filter over the lens, so the cameras are designed to function in the red end of the spectrum (not always a disadvantage for astronomy — see "Red Light Sky Photography", August 1976). The lens must be refocused for photography with blue-sensitive

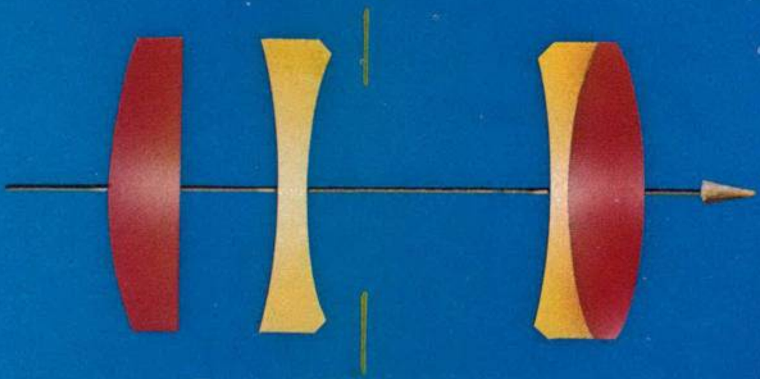
Lenses for Astrographs



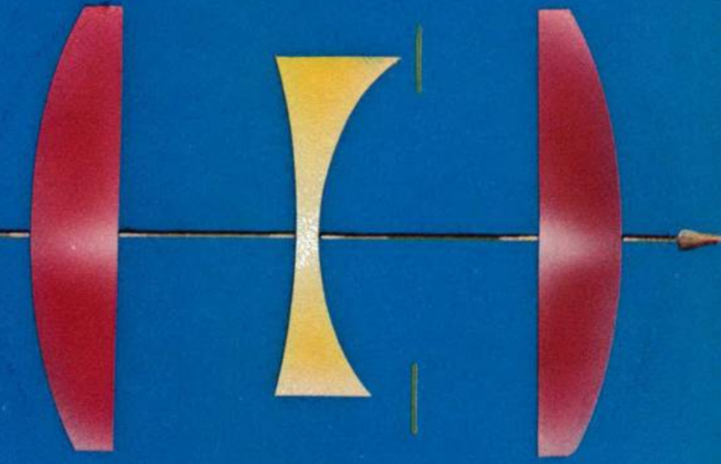
6" Metrogen f/6.3



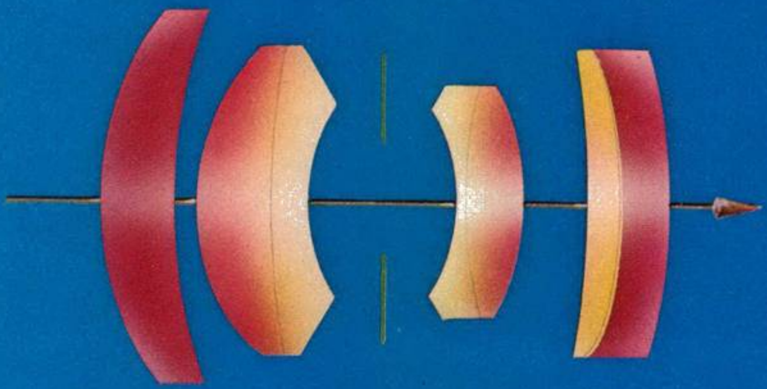
Bausch & Lomb 20" f/5.6 telephoto



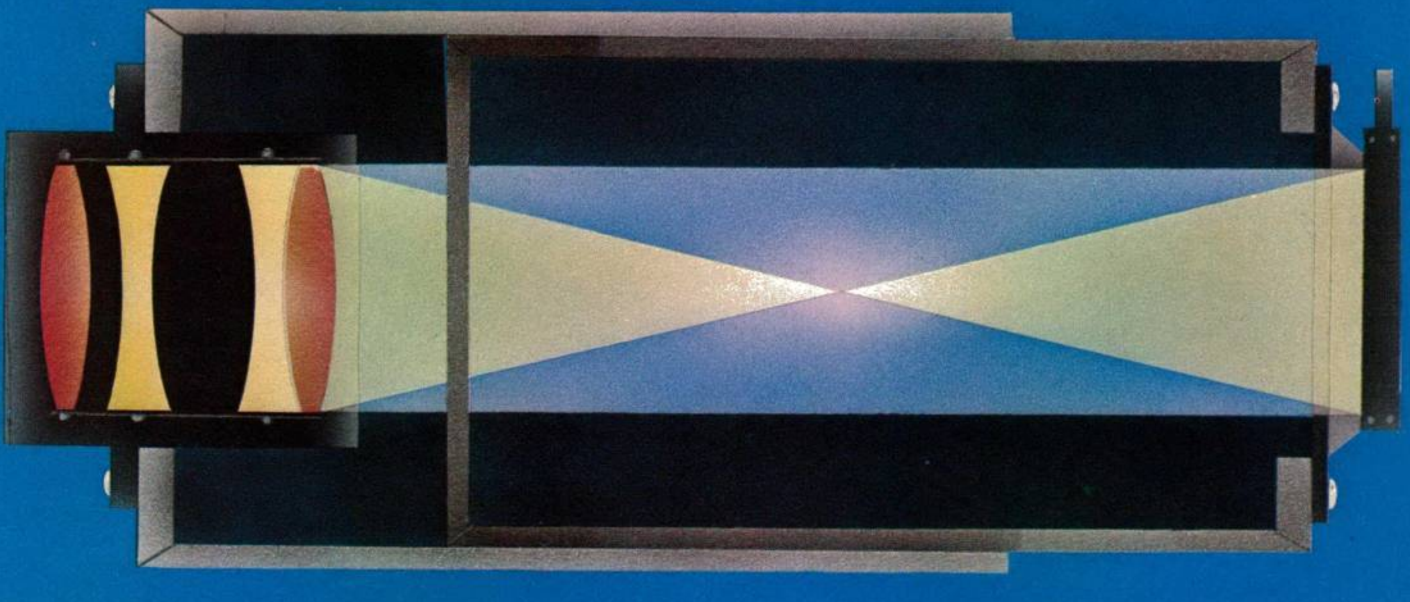
Tessar: 12" f/5 or 24" f/6



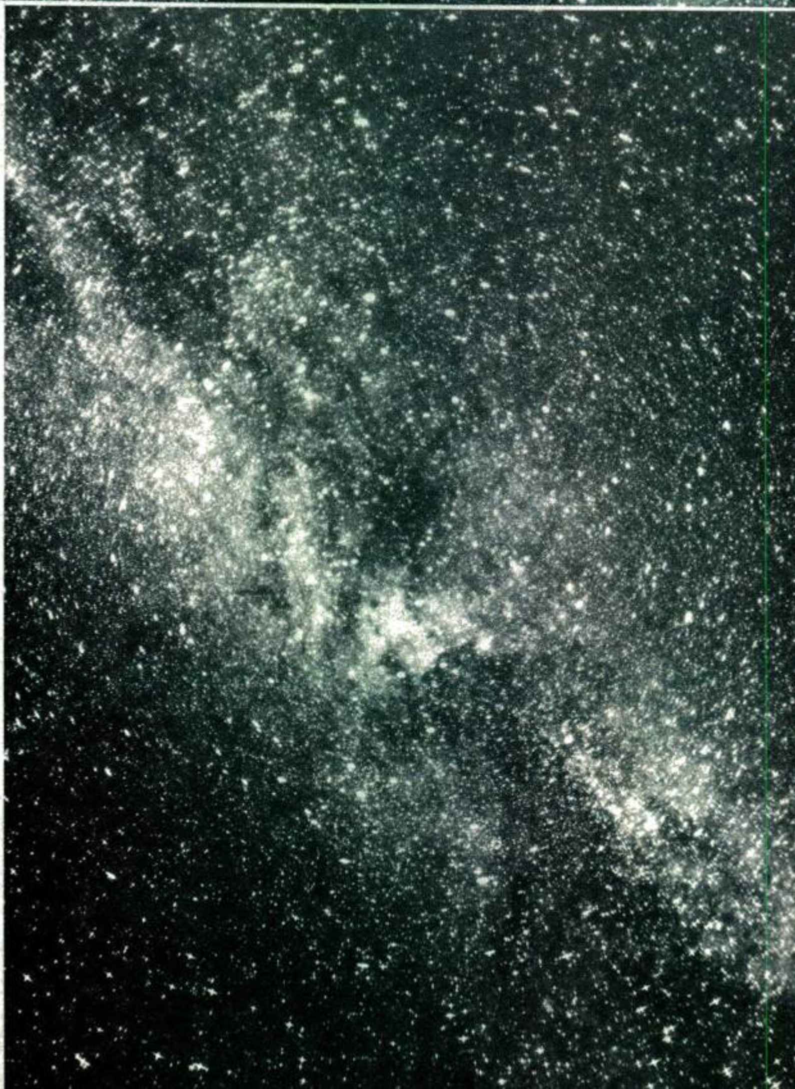
triplet lens



7" and 12" f/2.5 Ektar



An astrographic camera need not be complicated. Two telescoping boxes, the front one holding the lens and the rear one holding the plateholder, are all that's required for fine astrophotography. Artwork by Mark Paternostro.



plates. For "panchromatic" photography, a minus-ultraviolet filter would normally be used to prevent out-of-focus blue light from creating halos around bright stars.

The most common lenses you'll encounter on the U.S. surplus market are Metrogons, Aero-Ektars, Aero-Tessars, Aerostigmats, and several types of telephoto. Lenses were manufactured by a variety of makers, but most often by Kodak or Bausch and Lomb.

The *Metrogon* is a wide-angle lens of six inches focal length (153mm) and f/6.3 aperture, designed to cover a 90 degree angle on nine inch square film. They were used primarily for aerial mapping with a Fairchild K-17 camera. In the Tri-Metrogon arrangement, three cameras recorded a continuous horizon-to-horizon strip of territory as a plane flew over it. For stellar photography, Metrogons provide reasonable coverage of a 4 x 5 inch sheet of film if stopped down to f/8; on an 8 x 10 inch plate, some of them give good images at the corners and others don't. However, the superwide-angle 90 degree coverage, combined with star recording to 12th or 13th magnitudes, can provide interesting astrophotography.

Aero-Ektars were made for night photography with flash bombs or electronic flash. They are fast (f/2.5), and come in seven inch (178mm) and 12 inch (305mm) focus versions. By any standard, they're impressive pieces of glass (especially the 12 inch), and their speed would seem to make them valuable lenses for astrophotography. But even though the 12 inch lens was designed to cover 9 x 9 inch film in the K-19 camera, its circle of sharp definition is only two or three inches in diameter. By stopping the lens down to f/4 or f/5, good coverage of a 4 x 5 inch sheet film can be obtained. The seven inch version, designed for use with the K-21 or K-24 cameras, is good enough to cover a 4 x 5 inch film or plate wide open at f/2.5. Comet and Milky Way photographs with the "little" Ektar are very impressive.

The 12 inch f/5 *Aerostigmat* was the "normal lens" for reconnaissance over enemy territory with the K-17 and K-24 cameras. The lens is a Tessar type design, and covers a 4 x 5 inch film or plate quite well even at f/5; especially good definition is obtained with a red filter. For star field photography with a 4 x 5 format, the lens covers a 20 by 25 degree field — well suited for survey work. The 12 inch (300mm) focal length is not difficult to guide even with portable equipment.

Top: Starclouds and dustclouds are recorded in this 20 minute exposure of the constellation Scutum, obtained with a surplus aerial camera lens — an Aero-Tessar 24 inch f/6 — on a 103aF plate. Lower left: With a wide angle reconnaissance lens — a six inch focus Metrogon — the Milky Way in Sagittarius, Scutum, Ophiuchus and Aquila was recorded in a 60 minute exposure on Royal-X Pan 8 x 10 sheet film. Lower right: With the same film and camera, Cygnus and Cepheus required an 80 minute exposure.

Another lens, not very common now, that was used in reconnaissance photography was the 20 inch (508mm) focus f/5.6 telephoto lens which covers a 4 x 5 film or plate reasonably well. Many of these lenses were also used for reconnaissance by the Navy.

The most common astrocamera surplus optic is probably the 24 inch focus f/6 (610mm) lens, called an *Aero-Tessar* when made by Bausch and Lomb, and *Aero-Ektar* when made by Kodak. Used for reconnaissance with the K-17 and K-18 cameras, the lens covered either a 9 x 9 inch film or a 9 x 18 inch film. For star work, they will cover an 8 x 10 inch plate with satisfactory images, especially if used with a yellow filter. There is a wide range in quality with this lens, as improvements in design were incorporated throughout its wartime manufacture, but most of them are reliable. Usually, because of the cost of large plates, smaller 4 x 5 inch plates are used with this lens. You should, however, "design-in" the capability to hold 8 x 10 inch plates if you build an astrocamera with this lens. Image quality can be improved by stopping down to f/7 if the individual lens proves a bit fuzzy at f/6.

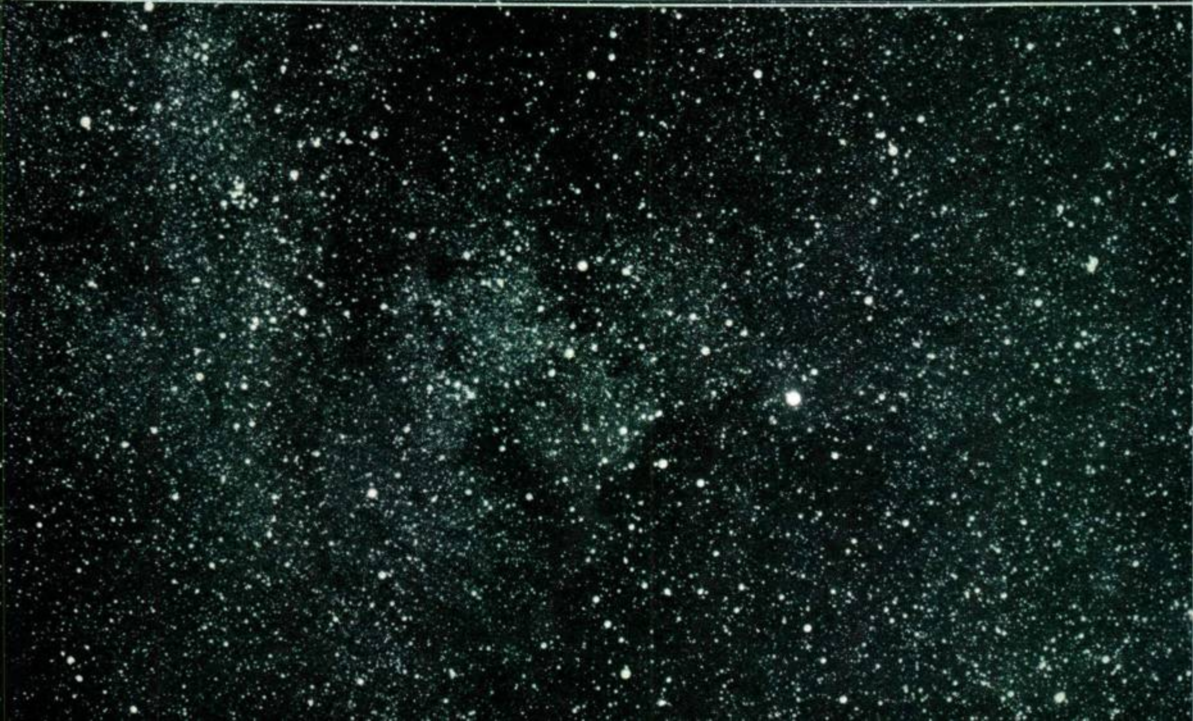
Finally, a 36 inch (915mm) focus f/8 *Telephoto* was introduced late in the war to cover the 9 x 18 inch film size of the K-18 camera. For astrophotography, the lens is somewhat slow and fuzzy. At this focal length, aerial lenses are no longer really satisfactory for astrophotography, but if you find one at a good price you'll certainly be able to use it.

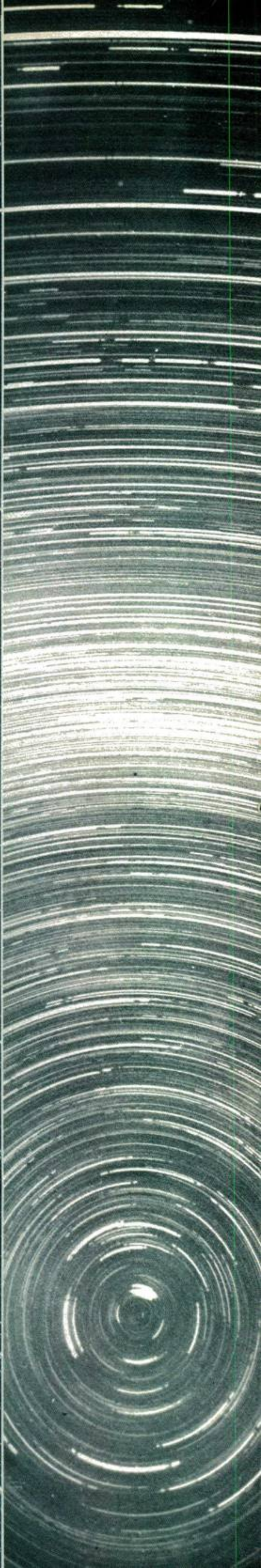
Of course, other lenses (some made in small quantities only) — including some made in other countries — may be satisfactory for astrophotography. The only way to find out is to test them — preferably before you buy them.

Commercially Available Lenses

Many lenses suitable for astrophotography are used on view cameras. Major sources of professional photographic supplies (such as Burke & James, 333 W. Lake St., Chicago, Ill. 60606) list dozens of lenses with excellent specifications. Lenses such as a 400mm f/5 triplet, and Tessar lenses by well known manufacturers like Schneider and Carl Meyer, are available — though prices tend to run into hundreds of dollars. Your local camera shop may have a few older "press" lenses — perhaps a 300mm f/6.3 lens that could cover a 4 x 5 inch plate — at a price that could be excellent. However, it is still best to check the performance of such lenses before buying.

Finally, there are the lenses made specifically for astrophotography: precision triplet and "vierlinser" designs built to give their best images in the blue light (the astronomer's traditional wavelength region). Carl Zeiss manufactures a series of renowned triplet lenses, up to a 49 inch focus f/7 lens worth several thousand dollars. In the U.S., further information can be obtained by





contacting Zeiss Co., 444 5th Ave., New York, N.Y. 10016. A French firm, Optique Boyer, makes a "Saphir" lens of very high quality; in the U.S., contact John Ross, Rolyn Optical Co., 300 Rolyn Pl., Arcadia, Calif. 91006. Rolyn also carries several other high quality (but less expensive) lenses, such as the four element Cooke type Coronar. Goto Optical Co. of Tokyo, Japan, manufactures a line of complete astrographic cameras (in the U.S., contact Mitsui and Company, 200 Park Ave., New York, N.Y. 10017).

The high prices of ultrahigh quality lenses may be discouraging, so you shouldn't forget the surplus aerial lenses. They are worth (new) far, far more than they're sold for today.

Astrographic Cameras

After you've found your lens, you'll have to build the camera for it; luckily, this is not too difficult. An astrographic camera body serves only to carry the lens and the film, holding them firmly positioned relative to each other. It may be round or square in cross section, and of course its length is determined by the focal length of the lens. Plywood, being readily workable and inexpensive, is often used: An arrangement of two lightweight boxes, one sliding inside the other, works well and is simple to construct. Exact dimensions are unimportant and no plans are really required — merely some common sense and neat, careful construction.

Film holders can be purchased from most professional photographic supply houses for very reasonable prices (especially considering they will probably never wear out). In the 4 x 5 inch size, you can get a new one for about $7, used for somewhat less, and about $16 for the 8 x 10 inch size. Two or three is all you'll probably need, since each holder carries two films. Plate holders are more expensive and harder to find, but you can usually order them through a camera store.

The film holder can be held in the camera back with a simple homemade frame with spring loaded metal strips. You can go "whole-hog" and purchase a professional camera back with a spring loaded ground glass focusing screen for around $100, or you may be able to salvage the back from an old press camera.

Mounting and Guiding

Small astrocomeras can be mounted piggyback, just as 35mm cameras can be. When the lens reaches a focal length of 12 inches or so, however, the camera's weight becomes great enough that you'll need to provide a solid attachment. For instance, instead of attaching the camera to the telescope, it could be attached directly to the mounting or substituted for the counterweight of the telescope. Larger cameras (those of 20 and 24 inches focal length) should be placed directly on a mounting large enough to carry at least a six inch reflector. The guidescope can then be carried piggyback on the camera. The largest cameras, such as the Zeiss 49 inch (1,200mm) focus f/7 triplet, must be mounted on massive mountings capable of precise tracking; such an instrument is certainly capable of serious work.

Guiding is no more difficult with a 300mm focus astrographic camera than it is with a 300mm telephoto lens on a 35mm camera — with the important exception that the polar axis of an astrograph must be better aligned than the narrow field 35mm telephoto lens. Polar misalignment causes the photographic field to appear to rotate around the guide star; thus, your wide field astrograph will be more sensitive to field rotations than the narrow-angle cameras. If you don't need to make large corrections in declination while guiding, your polar alignment is already good enough.

Film and Plates for Astrographic Cameras

Astrographs operate at f-ratios typical of Newtonian reflectors — between f/4.5 and f/8 — so that any film suitable for prime focus photography with a Newtonian is suitable for use in an astrograph. You'll usually find that the faster films are more desirable. In 4 x 5 inch sheet film, Royal Pan (ASA 650) and Royal-X Pan (ASA 1250) are your best bets; Tri-X, the 35mm Jack-of-all-trades, is slower in the 4 x 5 sheet film version and seems to have worse reciprocity failure. Both sheet films mentioned can be pushed very effectively to yield higher speed.

The 103a series spectroscopic emulsions are the best for effective astrophotos; being designed for astrophotography, they are high in contrast and speed, and low in reciprocity failure. Although 103a series emulsions are available on film base, it is better to buy them on glass backing. Glass stays flat during long astronomical exposures, and star images stay in critical focus. Glass plates may be ordered in quantities of 36 per box through Optica b/c, 4100 MacArthur Blvd., Oakland, Calif. 94619.

Astrographic Camera Philosophy

Astrographic cameras require a different approach than 35mm photography. Each picture may require 30 to 60 minutes exposure, so a long night's work may produce only a small number of plates or films. Each picture is important by itself — worth making a major effort for, and worth planning carefully. The payoff comes when you develop six or eight precious plates of carefully selected regions of the sky, and find perfect images of thousands of faint stars covering the still-wet negatives. ◆

The rich starfields shown at left were recorded with a 24 inch Aero-Tessar lens on Royal-X Pan 8 x 10 inch sheet film in 60 minute exposures. The top photo shows several bright clusters located in Auriga. Middle: The Pleiades and nearby dark nebulae are seen in this photo; at bottom is part of Cygnus, including Deneb, the North America nebula, and a half million stars. Right: Astrographic cameras produce starfilled trail pictures. This is a three hour exposure with a Metrogon.

The Man-of-the-Light-Year at Meade Instruments is Nicholas-Louis de Lacaille

It was he who first espied 87 naked eye stars in the mid-18th century South African skies. What's more —he resisted the temptation to name them for some time-worn demi-gods and -goddesses. He is very special to us not because this was a landmark sighting in the history of astronomy. Hardly. Rather it's because he made a constellation of a nondescript array of stars and called it "Telescopium".

Perhaps it seems a bit obvious for a telescope designer/manufacturer to capitalize on a sprinkling of stars that you have to force yourself to see as a telescope constellation.

Well, we don't blame anyone these days for being advertising-shy. But this is the way we happened onto our Man-of-the-Light-Year.

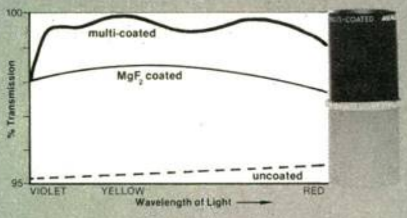
At Meade Instruments we're always taking a long, hard look at our products. At the way they meet the stringent requirements of serious amateur and professional astronomers. At the way they assemble into finely-meshed instruments under the gun of dead-eye tolerances. At the way they smoothly integrate themselves into our own telescope systems and even enhance the finest systems built by our competitors.

Like Lacaille, we are always on the alert for new and more exciting constellations that can be made with our components. This takes some doing when so many of our fine instruments are stars of such impressive magnitude that we might overlook the larger picture. Whenever this is about to happen we will get a call or visit from a customer who has been scanning our ads and not seeing the system for the components.

Together we make a sighting of his own Telescopium—the optimum interface of several Meade components. Our customers tell us that a helpful word or two of our technical counsel has saved them countless hours of unproductive ad-scanning.

Taking another leaf from Lacaille we call your attention to the system orientation that governs all our design and manufacturing—of everything from a color filter to a full-blown refracting telescope.

Our exclusive Meade Research-Grade Orthoscopic eyepieces are a case in point. To begin with, they are superior 4-element optical systems in their own right. As such, they are unsurpassed for color correction, resolution, and flatness-of-field. The lenses are figured to incredibly exacting tolerances and are 5-layer Multi-Coated to maximize light transmission and increase image contrast. The extent to which Multi-Coating enhances light transmission can be readily seen in the comparative curves.



For another thing, all six of our Research-Grade eyepieces are precisely parfocal: the observer need not re-focus the image each time he switches from one eyepiece to another.

And oh — a belated thanks to you, Nicholas-Louis de Lacaille. May your star shine brightly in the astronomer's firmament. Without you, we couldn't have made such a telling point about Meade optical systems.

PRODUCT DATA

1 - PHOTO-VISUAL COLOR FILTERS - Top quality optical glass, dyed in the mass, with excellent spectral homogeneity. Mounted in machined metal cells which thread directly into all our 1-1/4'' "Series 1" and "Research-Grade" eyepieces. Filters may be piggybacked. Listed by Wratten No. and color: **#8 Light Yellow - #11 Yellow-Green - #12 Yellow - #21 Orange - #23A Light Red - #25A Red - #47 Violet - #58 Green - #80A Medium Blue - Polarizer** (30% transmission) Each Filter:...**$5.75 ppd.** - Set of any 6:...**$32.50 ppd.** - Full set of 10:...**$52.50 ppd.**

2 - Series 1 ORTHOSCOPIC EYEPIECES (1-1/4'' or .965'' O.D.) - These Meade eyepieces are the largest selling orthoscopics in the world. Classical 4-element design, 45° field, fully coated, with precise corrections for color and field flatness. All 1-1/4'' barrels are threaded to accept our photo-visual filters directly. **Focal lengths: 4, 5, 6, 7, 9, 12.5, 18, 25mm - Each...$16.95 ppd.**

3 - Series 1 PARFOCAL ORTHOSCOPIC EYEPIECES (1-1/4'' O.D.) - As in (2) but parfocalized in all 8 focal lengths. **Each:...$18.95 ppd. - Set of any 4:...$72.95 ppd. Set of any 5:...$90.00 ppd. - Additional eyepieces: each...$18.00 ppd.**

4 - RESEARCH-GRADE ORTHOSCOPIC EYEPIECES with Multi-Coated, Parfocal Optics (1-1/4'' O.D.) - Acclaimed by amateur and professional astronomers everywhere to be the world's finest eyepieces. These 4-element systems are unsurpassed in resolution, color correction, and flatness of field. Air-to-glass surfaces are 5-layer multi-coated for maximum image contrast and light transmission. 45° field. Precisely parfocal. Barrels are threaded to accept our filters directly. **Focal lengths: 4, 7, 10.5, 16.8, 28mm each...$29.95 ppd. - Set of any 4:...$112.50 ppd. Set of any 4 plus Res. Gr. Erfle 20mm...$137.50 ppd. - Full set of 5 Res. Gr. Orthoscopics plus Res. Gr. Erfle 20mm...$165.00 ppd.** (Sets of 4, 5, or 6 eyepieces are shipped in fitted carrying case (see (27) at no additional charge).
RESEARCH-GRADE ERFLE 20mm (1-1/4'' O.D.) - Parfocalized with our Research-Grade Orthoscopics and 5-layer multi-coated. Apparent field in excess of 75° for breathtaking wide-angle observations. Barrel accepts our filters directly. **$36.50 ppd.**

5 - Series 1 KELLNER EYEPIECES (1-1/4'' O.D.) - Highly corrected, 3-element design, fully coated. The best in moderately priced eyepieces. Barrels threaded for our filters. **Focal lengths: 6, 12, 25mm each...$11.50 ppd. - 40mm Wide Field...$13.50 ppd.**

6. - KELLNER 40mm EXTRA-WIDE-FIELD (1-1/4'' O.D.) - Yields widest field obtainable in 1-1/4'' O.D. Enlarged field lens and special field-flattening optics with long eye relief. Barrel accepts our filters... **$22.75 ppd.**

7 - Series 1 ERFLE 20mm (1-1/4'' O.D.) - An advanced 5-element system with fully coated, color corrected optics. Wide 65° field. Barrel accepts our filters. **$23.95 ppd.**

8 - ZOOM ORTHOSCOPIC EYEPIECE (1-1/4'' O.D.) - Zooms instantly from 8.4mm to 21mm, with excellent image corrections at all powers. Wide 50° field at 8.4mm. Fully coated optics...**$32.95 ppd. - Filter adapter #004**: couples our filters to above eyepiece...**$1.00 ppd.**

9 - ZOOM KELLNER EYEPIECE (.965'' O.D.) - Fine 4-element design. Zoom range 7.5mm-22.5mm. Fully coated optics...**$24.95 ppd.**

SUPER-WIDE-FIELD EYEPIECES (2''O.D.) - Premium-quality wide-field eyepieces for 2'' focusers. The ultimate in rich-field performance. Fully coated.
10 - ERFLE 32mm (2'' O.D.) - Sophisticated 5-element optical system. Wide, flat 65° field...**$67.50 ppd.**
11 - KELLNER 60mm (2'' O.D.) - Low power, long eye relief. Ideal for deep-space observations...**$29.50 ppd.**

12 - ERFLE 32mm (1-1/4'' O.D.) - As in (10), but with standard 1-1/4'' barrel, threaded for our filters. 60° field...**$67.50.**

13 - .965'' EYEPIECES - (phone, or request catalog, for details).

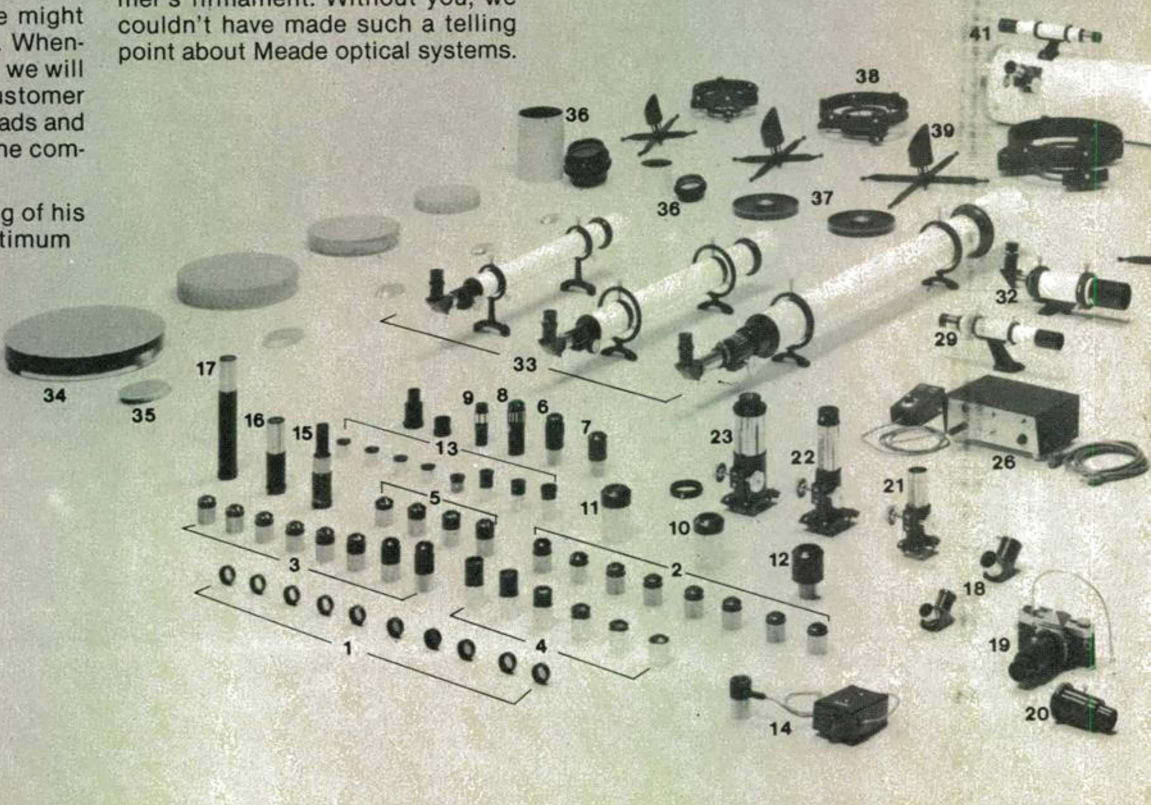
14 - ILLUMINATED RETICLE GUIDING EYEPIECE (1-1/4'' or .965'' O.D.) - For professional-level photographic guiding. Kellner 12mm optical system, with precisely focusable 4-line glass reticle. Remote brightness control and 3 ft. cable. (Extension cables available) Complete...**$37.50 ppd.**
Micrometer Reticle: Full-field scale for accurate measurements of double star separations, planetary angular diameters, etc. Interchanges with standard 4-line reticle...**$11.95 ppd.**

15 - 2X ACHROMATIC BARLOW LENS (1-1/4''O.D.) - A high resolution, coated, negative achromat with excellent corrections for spherical and chromatic aberrations. **$18.75 ppd.**

16, 17 - 2X AND 3X TELENEGATIVE AMPLIFIERS (1-1/4'' O.D.) - The world's finest Barlow lenses. Full 26mm clear aperture, with virtually flawless optical corrections at all photo-visual wavelengths. Produces optimum performance on telescopes of any focal ratio. Fully coated. (16) **2X Model 122...$29.50 ppd.** (17) **3X Model 123...$32.50 ppd. - Combination 2X and 3X Model 124...$39.50 ppd.**

18 - DIAGONAL PRISMS - Quality, right-angle prisms, fully coated. **1-1/4'' O.D....$14.95 ppd. - .965'' O.D....$10.95 ppd.**

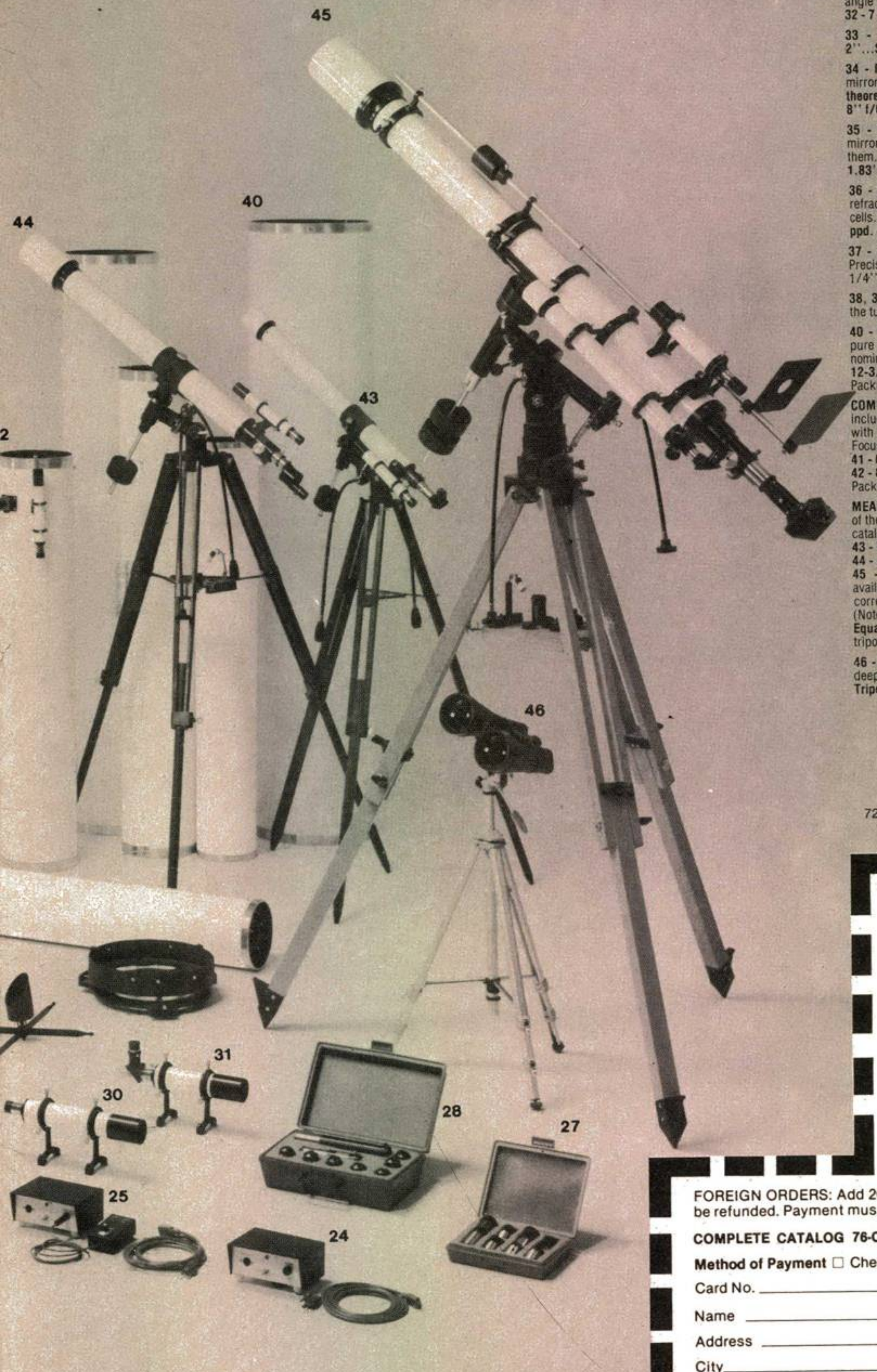
19 - OLYMPUS OM-1 ASTROCAMERA - One of the world's great astrocameras. (Phone or request catalog for details.)...**From $229.50.**



20 - DELUXE CAMERA ADAPTERS - Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum. All units permit both eyepiece projection and first (prime) focus photography. Specify either .965'' or 1-1/4'' focuser. (If for Celestron, please specify.) All 1-1/4'' units are threaded for our filters. **Pentax, Praktica, Yashica, Mamiya...$16.75 ppd - Exakta, Nikon, Canon, Minolta, Miranda, Konica...$24.75 ppd. - Olympus OM-1...$27.75 ppd.**

RACK-AND-PINION FOCUSERS - Precision metal construction. All 3 models include helical-cut rack for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1-1/4'' eyepiece holders. **Each focuser is guaranteed to be the finest obtainable in its class.**
21 - Model #67 - Strong, lightweight design for 4'' to 10'' telescopes. 2-3/16'' travel. An excellent value...**$14.75 ppd.**
22 - Model #640 - A heavy-duty deluxe focuser for 6'' to 16'' telescopes. Full 3'' travel for both visual and photographic applications...**$21.75 ppd.**

23 - Model #680 - Our finest focuser. Accepts both 1-1/4'' and 2'' eyepieces. Full 3'' travel for photo or visual observing with 6'' to 16'' telescopes...**$29.95 ppd.**



VARIABLE FREQUENCY DRIVE CORRECTORS - Quality, temperature compensated circuitry for precise electronic guiding. Each model will drive telescopes to 14'' aperture. 20 ft. battery cables, instructions included.
24 - Model #24 - Uses 12v. D.C. Frequency variable between 50-70Hz with knob attached to power box. An excellent value...**$49.50 ppd.**
25 - Model #29 - Uses 12v. D.C. Remote control box with fast-slow buttons and variable center frequency dial for tracking at solar, lunar, or planetary rates...**$62.50 ppd.**
26 - Model #33 - Uses 12v. D.C. or 110v. A.C. Other features identical to Model 29...**$89.50 ppd.**

ACCESSORY CASES - Rugged polyethylene, for dust-free protection of eyepieces, filters, Barlows, etc. For either 1-1/4'' or .965'' accessories. Die-cut foam lining.
27 - Model #51 - 7'' x 8-1/2''...$7.95 ppd.
28 - Model #54 - 8'' x 12''...$10.95 ppd.

VIEWFINDERS - Each with coated, achromatic objective and crosshair eyepiece.
29 - 6 x 30mm: Fine, 4° wide-field finder. Thousands now in use. 2-ring bracket included...**$14.75 ppd.**
30 - 7 x 50 mm: Large 50mm aperture. Sharp, brilliant images. (Not for use with prism.)...**$21.75 ppd. - Brackets: $7.95/pr.**
31 - 7 x 50mm Right-Angle: 50mm aperture, for both straight-through and right-angle viewing. Prism included...**$29.95 ppd. - Brackets: $7.95/Pr.**
32 - 7 x 50mm Right-Angle: As above, but with bracket for Celestron 8...**$44.95 ppd.**

33 - PHOTO-GUIDE TELESCOPES - (Phone or request catalog for details.) **2''...$34.50 - 2.4''...$65.00 - 3.1''...$138.00**

34 - PARABOLIC PRIMARY MIRRORS - Professional quality hand figured Pyrex mirrors, aluminized and quartz overcoated. **Each mirror is guaranteed to reach all theoretical limits of performance. 6'' f/8...$49.95 ppd. - 10'' f/6...$119.50 ppd. 8'' f/6 or f/7.5...$79.95 ppd. - 12-1/2'' f/6...$217.50 ppd.**

35 - ELLIPTICAL SECONDARIES - For optimum performance with any primary mirrors. Aluminized, overcoated. As optically flat as master opticians can make them. Minor axis sizes shown, postpaid: **1.30''...$8.00 - 1.52''...$11.50 - 1.83''...$13.50 - 2.14''...$16.50 - 2.60''...$19.50.**

36 - OBJECTIVE LENSES - As used in Meade guide telescopes and equatorial refractors. Air-spaced, achromatic, fully coated. Mounted in machined, threaded cells. Dewcap and dustcap included. **2'' f/12...$14.50 ppd. - 2.4'' f/15...$29.50 ppd. - 3.1'' f/15...$74.50 ppd.**

37 - SETTING CIRCLES - Die-cast aluminum, 6'' diameter. Machine engraved. Precision guaranteed. Standard 1-1/2'' bore:...**$35.00/pr.** Other bores (from 1/4'' to 2''): **add $1.50 per circle.**

38, 39 - MIRROR CELLS AND SPIDERS/DIAGONAL HOLDERS are available to fit the tubing below. Phone, or request catalog, for details.

40 - FIBERLITE TELESCOPE TUBES - 20% more rigid, yet 40% lighter, than pure fiberglass, with low thermal conductivity. Polished end rings available at nominal cost. Partial price list: **7'' I.D. x 50''...$29.00 - 9-1/4'' I.D. x 60''...$39.00 12-3/8'' I.D. x 62''...$58.00 - 12-3/8'' I.D. x 72''...$74.00**
Packing charge on tubes...**$4.00.**

COMPLETE OPTICAL TUBE ASSEMBLIES - Fully Assembled. Each assembly includes the premium quality Meade components described above: Fiberlite tube with end rings, primary mirror and cell, spider and secondary mirror, Model #67 Focuser, 6 x 30mm viewfinder. Shipping charges collect.
41 - 6'' f/8 tube assembly...$144.95
42 - 8'' f/6 tube assembly...$189.95
Packing charge on tube assemblies...**$4.00**

MEADE EQUATORIAL REFRACTORS - Whether beginning or serious amateur, one of these superb instruments will fit your observing requirements. Phone or request catalog for details.
43 - Model #291: 2.4'' Equatorial Refractor...$195.00
44 - Model #300: 3.1'' Equatorial Refractor...$325.00
45 - Models #420 - #440: 4'' Equatorial and Photo-Equatorial Refractors, available with guide telescope, illuminated reticle eyepiece, motor drive, frequency corrector, astrocamera. **From $1068.00**
(Note: first deliveries on 4'' models - Dec., 1976)
Equatorial Mounts - Each includes complete mount, circles, 2 cables, hardwood tripod. **Mount for Model #291...$95.00 - Mount for Model #300...$157.00**

46 - 20 x 80mm ASTRONOMICAL BINOCULARS - Coated optics. Magnificent for deep-space observing...**$127.50 ppd.** - (Delivery: November, 1976). **Bushnell Tripod:** fully adjustable...**$49.50 ppd.**

MEADE INSTRUMENTS
721 West 16th Street, Costa Mesa, Calif. 92627 • (714) 646-9281

MAIL ORDERS: Circle numbers for items desired and write your specific requirements on a separate sheet—or use the order form which accompanies our catalog.

1 2 3 4 5 6 7 8 9 10 11 12
13 14 15 16 17 18 19 20 21 22 23 24
25 26 27 28 29 30 31 32 33 34 35
36 37 38 39 40 41 42 43 44 45 46

PAYMENT: Personal or bank check, money order, or credit card (BankAmericard or Master Charge)

TELEPHONE ORDERS: accepted with payment either COD or credit card (we do not accept collect calls).

SHIPMENT: All orders are processed for shipment within 24 hours of receipt.

FOREIGN ORDERS: Add 20% to cover Air Parcel Post charges—any excess will be refunded. Payment must be made by bank check in $ U.S.

COMPLETE CATALOG 76-C — $1.00 (Catalog free with any order)

Method of Payment ☐ Check or Money Order ☐ BankAmericard ☐ Master Charge

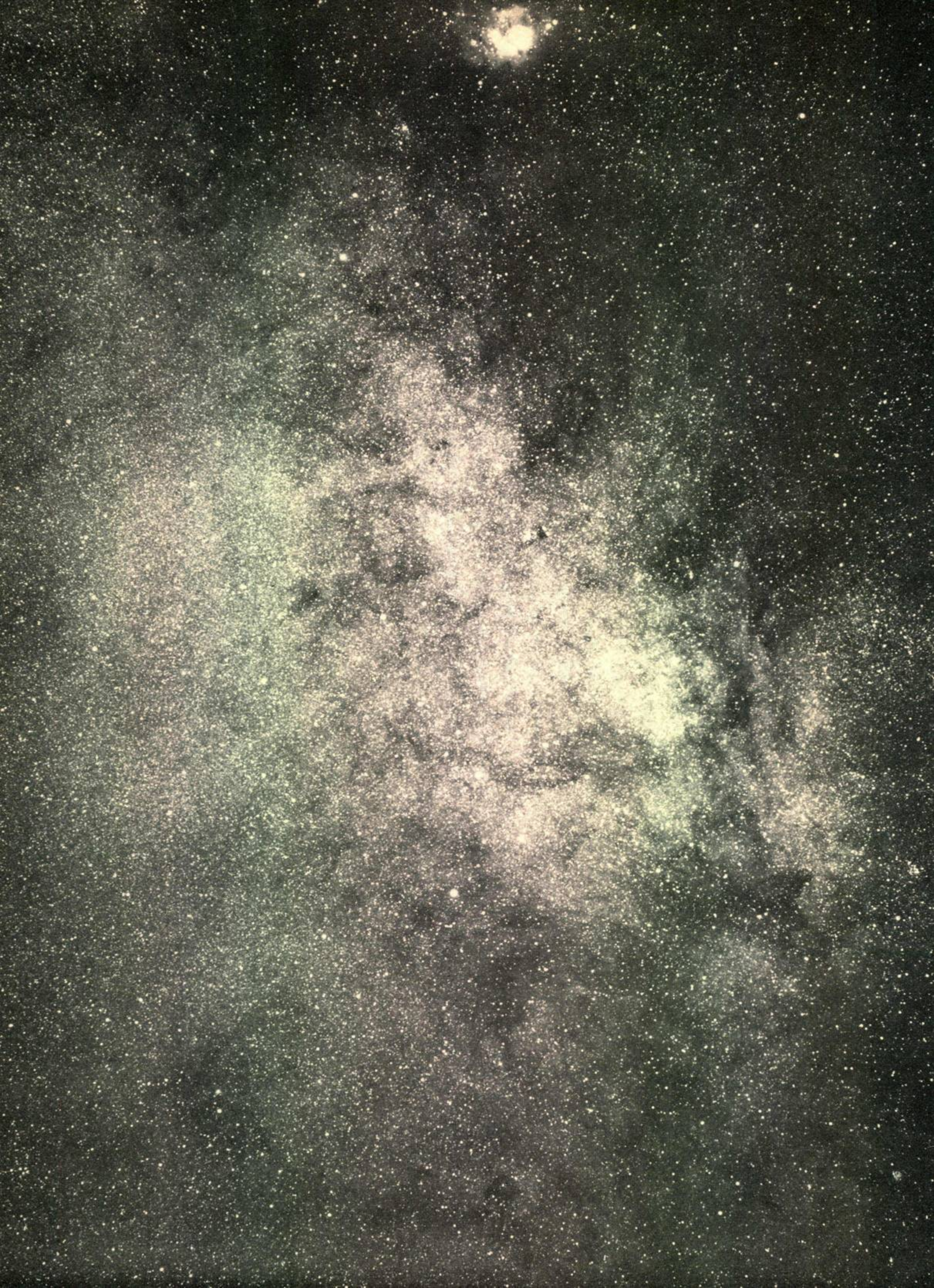
Card No. ____________________ Expiration Date / /

Name ____________________

Address ____________________

City____________ State________ Zip________

MEADE INSTRUMENTS
721 West 16th Street, Costa Mesa, Calif. 92627 • (714) 646-9281



Jupiter Dominates November Sky

Planet watchers will find more and more to please them as the year nears its end. The giant planet Jupiter reaches opposition this month; Venus and Saturn are brightening as they approach their best positions for observing, and a penumbral eclipse of the moon will be available to those with keen eyesight. Other treats are also in store for November; move your telescope outside and take a look!

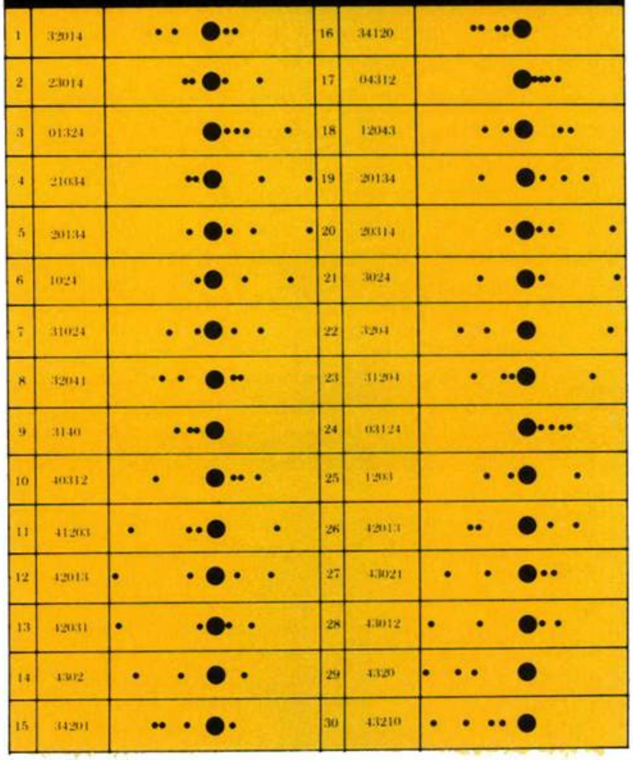
Jupiter

On Nov. 18, Jupiter is at opposition in the western part of the constellation Taurus. You're not likely to confuse the planet with any nearby stars; shining at magnitude -2.4 all month, Jupiter far overpowers the nearby first magnitude star Aldebaran. Even if you're an absolute beginner, there's no mistaking Jupiter, and you can find it merely by looking east any evening this month. More experienced observers can note its position just southwest of the Pleiades.

Telescope users can derive enormous satisfaction from the appearance of Jupiter in their instruments. Even a small refractor is sufficient to show cloud bands and the Great Red Spot, while larger apertures provide such a wealth of detail that the sight is apt to take your breath away. Those rare, fleeting moments of good seeing are worth waiting for; the sudden view of the incredibly detailed planet is not something you'll easily forget.

The Great Sagittarius Starcloud lies close to the direction of the galactic center. Outlined by huge clouds of light-absorbing dust, the starcloud is the richest and most brilliant section of the Milky Way. The Lagoon nebula shines at top. This 60 minute exposure was made on an 8 x 10 inch 103aF glass plate. An f/7 Zeiss triplet lens with an effective focal length of 49 inches was used, mounted in a home built astrographic camera. Photograph by I. Saulietis.

November Satellites of Jupiter
11:00 p.m. EST, 8:00 p.m. PST



1	32014	16	34120
2	23014	17	04312
3	01324	18	12043
4	21034	19	20134
5	20134	20	20314
6	1024	21	3024
7	31024	22	3204
8	32041	23	31204
9	3140	24	03124
10	40312	25	1203
11	41203	26	42013
12	42013	27	43021
13	42031	28	43012
14	4302	29	4320
15	34201	30	43210

The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about11p.m. (EST) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1=Io; 2=Europa; 3=Ganymede; 4=Callisto, and 0= Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.

Positions of Jovian Satellites VI and VII

Date	Jupiter		VI (Himalia)		VII (Elara)	
	R.A.	Dec.	R.A.	Dec.	R.A.	Dec.
Nov. 1	$3^{h}45^{m}12''$	+18°39'21"	$3^{h}48^{m}10''$	+19°27'03"	$3^{h}42^{m}57''$	+18°00'45"
Nov. 5	$3^{h}43^{m}08''$	+18°32'46"	$3^{h}45^{m}50''$	+19°19'29"	$3^{h}41^{m}13''$	+17°53'40"
Nov. 9	$3^{h}40^{m}58''$	+18°25'55"	$3^{h}43^{m}22''$	+19°11'13"	$3^{h}39^{m}25''$	+17°46'37"
Nov. 13	$3^{h}38^{m}46''$	+18°18'52"	$3^{h}40^{m}50''$	+19°02'22"	$3^{h}37^{m}36''$	+17°39'34"
Nov. 17	$3^{h}36^{m}31''$	+18°11'41"	$3^{h}38^{m}15''$	+18°52'59"	$3^{h}35^{m}45''$	+17°32'41"
Nov. 21	$3^{h}34^{m}17''$	+18°04'29"	$3^{h}35^{m}39''$	+18°43'17"	$3^{h}33^{m}55''$	+17°26'05"
Nov. 25	$3^{h}32^{m}05''$	+17°57'22"	$3^{h}33^{m}05''$	+18°33'16"	$3^{h}32^{m}07''$	+17°19'52"
Nov. 29	$3^{h}29^{m}56''$	+17°50'26"	$3^{h}30^{m}34''$	+18°23'08"	$3^{h}30^{m}22''$	+17°14'08"

Positions given are for 7 p.m. EST

Jupiter's surface is divided into *zones* and *belts*; the dark colored belts cross the planet's disk, separating the light colored zones from one another. The differences in hue result from the height of clouds in the atmosphere; belts are several miles deeper than zones. (Remember that when we discuss Jupiter's surface, we are actually talking about the top of its atmosphere.) Various surface features such as the Red Spot are found between the belts. The Red Spot itself, has been in existence for at least 300 years; other surface phenomena are more transient, lasting for months, weeks, or sometimes only days. If you watch Jupiter every night for a week or more, you'll easily notice the constant shifting and changing appearance of its surface. In addition, Jupiter rotates so quickly (taking slightly less than 10 hours) that new surface features are coming into view and passing across Jupiter's disk all the time. Long November nights are ideal for this kind of observing; you can witness a complete passage of the Red Spot, or some other feature, across the disk in a single night.

Jupiter's four large moons put on a never-ending show that changes nightly — and even within a single night! It's easy to become as inveterate a Galilean satellite-watcher as a Jovian cloud-watcher; transient phenomena are among the most fascinating things astronomy has to offer. Check the positions you observe against our "Satellites of Jupiter" chart on page 43, and watch how the moons slowly change their positions through the night. You can become so familiar with the moons that you can learn to identify them at a glance, without even needing the chart. The four moons are not equal in brightness, making their identification even simpler: Ganymede, at magnitude 4.6, is the brightest, followed by Io (5.0), Europa (5.3), and Callisto (5.6).

If you have a large telescope (eight inches or more), and are in the mood for a real challenge, why not try to find a few of Jupiter's smaller satellites? Moons VI and VII (Himalia and Elara) are of magnitudes 14.7 and 16.0 respectively, and should be within reach of large aperture instruments. To find these tiny moons, you'll need detailed star charts to be able to distinguish which of the tiny dots of light you'll see are actually the satellites. You'll also have to be certain that your setting circles are in perfect working order so you can pinpoint the moons accurately — but if you're up to the challenge, give it a try. Probably your best bet is photography; a 45 minute or one hour guided exposure should show the tiny satellites against

Satellite Shadows on Jupiter

Date	Satellite	Transit Begins (EST)	Transit Ends (EST)
Nov. 5	1	3:07 a.m.	5:15 a.m.
5-6	3	11:20 p.m.	12:32 a.m.
6	1	9:35 p.m.	11:45 p.m.
7	2	4:10 a.m.	6:44 a.m.
10	2	5:29 p.m.	8:03 p.m.
12	1	5:01 a.m.	7:11 a.m.
13	3	2:21 a.m.	4:32 a.m.
13-14	1	11:30 p.m.	1:39 a.m.
15	1	5:58 p.m.	8:08 p.m.
17	2	8:06 p.m.	10:40 p.m.
21	1	1:24 a.m.	3:34 a.m.
22	1	7:53 p.m.	10:03 p.m.
24-25	2	10:43 p.m.	1:16 a.m.
28	1	3:19 a.m.	5:29 a.m.
29	1	9:48 p.m.	11:53 p.m.

1 = Io **3 = Ganymede**
2 = Europa **4 = Callisto**

Upper: In these two photos taken on different dates near first quarter moon, large sections of maria gradually become visible along the terminator. Both photos are one second exposures on High Speed Ektachrome, obtained through a 2.4 inch Meade refractor in a first attempt at astrophotography. Photographs by Fred Hafeli. At lower left is another initial try at astrophotography — this time of the Lagoon nebula (M-8). This photo on GAF 500, taken through a home built eight inch f/5 Newtonian, closely matches M-8's visual appearance; delicate wisps of nebulosity twine through the numerous visible stars. Photograph by Dale Lightfoot. Compare this picture of the Lagoon with that at lower right; much more nebulosity is visible, giving the Lagoon its familiar shape. GAF 200 film and a home built f/5 Newtonian were used to obtain this shot. Photograph by Walter Hamler.

Four constellation photographs appear on these pages. Above left: The small constellation Lyra, headed by first magnitude Vega, shines in a rich field in this 10 minute exposure on High Speed Ektachrome. Above right: This is a 10 minute exposure, also on High Speed Ektachrome, of the tiny groups Sagitta and Delphinus — both small but distinctive. Opposite left: The Northern Cross in Cygnus is outlined in this 10 minute exposure on Tri-X film; the Cygnus Starcloud in the Milky Way shines faintly in the background. Opposite right: First magnitude Altair, flanked by dimmer companions, is the distinguishing feature of Aquila, captured in this 10 minute exposure on Tri-X. All four of these pictures were obtained through a 50mm lens, at f/2.8 for the color shots and f/1.9 for black and white. Photographs by Robert Gewin.

the star background. Photograph them again in a week and they will have moved. Your result will look somewhat like a series of asteroid pictures. Check the accompanying table for positions of VI and VII this month; around Jupiter's opposition date is the optimum viewing time.

Jupiter moves retrograde throughout the month. On the 18th, it has an equatorial diameter of 48.95 seconds and a polar diameter of 45.69 seconds of arc; it will be located slightly more than 374 million miles from Earth.

Venus

Jupiter may command your view during the later hours of the night, but during the early part of the evening it is outclassed by brilliant Venus, approaching a greatest eastern elongation date in early 1977. During November, Venus' magnitude increases from -3.5 to -3.6; its disk is about 3/4 illuminated, and its diameter increases from 13.2 to 15.54 seconds of arc. Sparkling in the southwest for about two hours after sunset, Venus will have traveled through most of Sagittarius by month's end.

Saturn

The ringed planet can be found very near the Cancer/Leo border throughout November. Saturn begins retrograde movement on the 28th; it will reach opposition on Feb. 2, 1977. Rising just befor midnight, the planet's magnitude is +0.6 during most of the month. Its diameter increases from 18.16 to 19.11 seconds of arc as it moves from 855 to 811 million miles from Earth.

Vesta

Another member of the solar system begins retrograde motion this month. The minor planet Vesta, due to reach opposition on Jan. 9, 1977, starts to move backward through the constellation Gemini on Nov. 22. Its magnitude on that date is 7.7, and it can be found about three degrees southwest of Zeta Geminorum. All of the "big four" asteroids will reach opposition during the first half of 1977; detailed information on each will be published in future issues of ASTRONOMY.

Mercury, Mars

Both these planets are in conjunction with the

sun in November — Mercury on the 7th and Mars on the 25th — and are too close to the sun for observation.

Uranus, Neptune, Pluto

The outer planets will all be in poor positions for viewing until March 1977.

Meteor Showers

Three meteor showers share the limelight during November. Unfortunately, the moon will interfere with observations of all three.

During the first week of November, the Taurid meteors fall at the rate of about 15 per hour. Their radiant point is just south of the Pleiades, and the date of maximum is Nov. 4. But the full moon, only two days later, will blot out all but the brightest.

The same is true for the Andromedids on the 14th and the Leonids on the 16th; the last quarter moon, shining throughout the early morning hours (when meteors are seen to best advantage), will cancel out any effect that these unpredictable showers may be able to produce. The Andromedids are slow and fairly dim, while the Leonids are fast and bright. Both showers have put on exceptional displays in the past, and diehard observers may be willing to brave the moonlight just in case something extraordinary happens again this year.

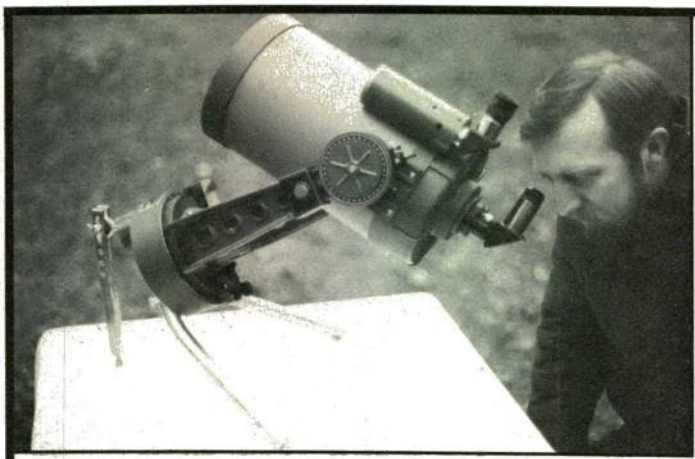
Lunar Eclipse

Those who weren't fortunate enough to make the trip to Australia in October to observe the total solar eclipse may be able to derive some comfort from the lunar eclipse that occurs on Nov. 6. Any comfort, however, is liable to be very small as the moon will enter no farther into Earth's shadow than the penumbra. Furthermore, the eclipse begins long before moonrise on North America's eastern coast, and will be ending at just about the time that the sky will be dark enough for observers to see what's going on.

The moon will enter the penumbra (the lighter portion of Earth's shadow) at 3:46 p.m. EST. Mid-eclipse occurs at 6:01 p.m. EST (sunset is not until about 40 minutes later), and the eclipse ends at 8:17 p.m. EST.

Because this is only a penumbral eclipse, the moon will not grow very dark; it will be quite difficult to detect any shadow on the moon's surface. Penumbral eclipses are difficult enough to observe even when they occur at midnight, and this one is in progress before the sun sets. Observers on the east coast may be able to detect a slight darkening of the lunar disk; those farther west are unlikely to see anything but the moon.

To add to the frustration, there will not be another total lunar eclipse for the duration of 1977.



BUY YOUR NEW CELESTRON® 5 OR 8 TELESCOPE

from TUTHILL

Your BANKAMERICARD welcome here

master charge THE INTERBANK CARD

Stock Delivery

Demonstrations and Personal Consultation

PRESENT CELESTRON OWNERS: Would you like to have increased protection from dewing — make lining up on the celestial pole a snap without leveling your tripod or knowing your latitude — look at the zenith easily with a large variable-power finder — adjust the tripod height for sitting or standing — increase the fine adjustment of the right-ascension knob — see the setting circles with built-in lights — have a five-pound sturdy portable equatorial mount which duplicates the wedge and tripod function but which stores in the box — motorize your manual declination adjustment — increase your declination circle resolution five times — have a VELVET TOUCH™ helical eyepiece focuser — have a Precision Polar Axis Locator — carry your valuable scope securely with a sturdy retractable handle or put a UNITRON UNIHEX™ OR DEUTRON™ on your CELESTRON?
WRITE TODAY for more information on these unique items that will enhance your pleasure in using these world-reknowned telescopes. We stock all standard CELESTRON accessories.

SEND FOR OUR NEW FREE CATALOG which will help you select items to enjoy more fully your exciting hobby. Some of the items illustrated are:

• **SOLAR-SKREEN**™ — Patented safe unsurpassed sunspot resolution. Keeps all heat out of your scope	*From $14.00*
• **LUNA-SHADE**™ — For comfortable viewing of full or gibbous moon	*From $14.00*
• **STEREOOCULAR**™ — For a new three-dimensional viewing effect	*From $244.00*
• **STAR-TRAP ELECTRONIC EYEBALL**™ — Makes deep-sky photography easy and manual guiding obsolete	*$125.00*
• **STAR-TRAP SUPER DRIVE CORRECTOR**™ — At last: both right ascension and declination control. Includes declination motor	*$155.00*
• **STAR-TRAP ILLUMINATED RETICLE EYEPIECE**™ —Built-in battery, metallic crosshairs, and red light-emitting diodes	*$44.00*
• **ASTRO-TULE**™ — Focus cameras with ease; test optics. Includes eyepiece	*From $33.00*

- **EYEPIECES**™— New low-cost, wide-field 1-1/4" Orthoscopic and Brandon Erfle eyepieces, large prism diagonals, Dakin Barlow, and other essentials.

ASK ABOUT OUR OFFER OF A FREE SOLAR-SKREEN FOR YOUR SCOPE.

ROGER W. TUTHILL

Box 1086A, 11 Tanglewood Lane, Mountainside, N. J. 07092
Telephone 201-232-1786

WE HONOR MASTER CHARGE AND BANKAMERICARD.
MONEY-BACK GUARANTEE ON ALL PRODUCTS WE SELL.

ANNOUNCING FROM OUR LABORATORIES

THE TUTHILL DRIVE SYSTEM

A miniature motor-driven equatorial mount

Left: Our system converts your camera tripod to equatorially drive your 35-mm. SLR, binoculars, or small scope ..... *Only $99.50*

THE JUNIOR SCIENTIST

The famous 80-mm. f/6 UNITRON refractor on a TUTHILL DRIVE fitted with a tripod adjustable for latitude. 20-60x.

Complete unit *$193.50*

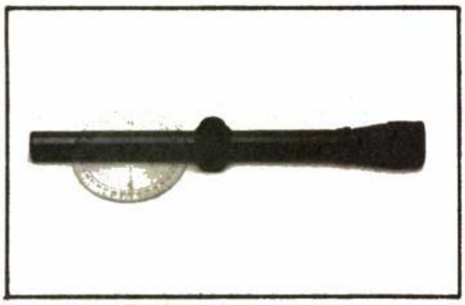
TUTHILL DRIVE and tripod *$112.50*

THE NEW TUTHILL DRIVE SYSTEM is the heart of this low-cost easy-to-use lightweight equatorially driven support for all kinds of astronomical equipment. It includes built-in two-axis preadjusted safety clutches, usually needs no counterweights, has large stiff polar and declination axes, has a 117-volt 60-hertz motor with a smooth worm drive and a tubular Polaris locator. It is the ideal scope support for that small refractor which is gathering dust. It can be supplied with a tripod or pipe support, or use your own tripod. It can be fitted with the Precision Polar Axis Finder.

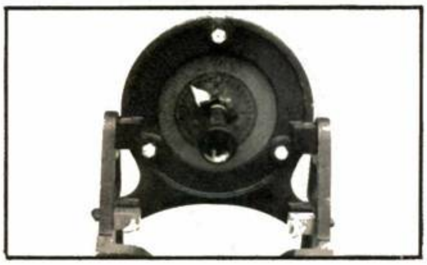
The **TUTHILL DRIVE SYSTEM** eliminates the need to use your big scope to piggyback your 35-mm. SLR to get wide-angle shots of comets, meteors, or constellations.

AT LAST A PRECISION POLAR AXIS FINDER

A boon to the serious astrophotographer



Finder scope and dial

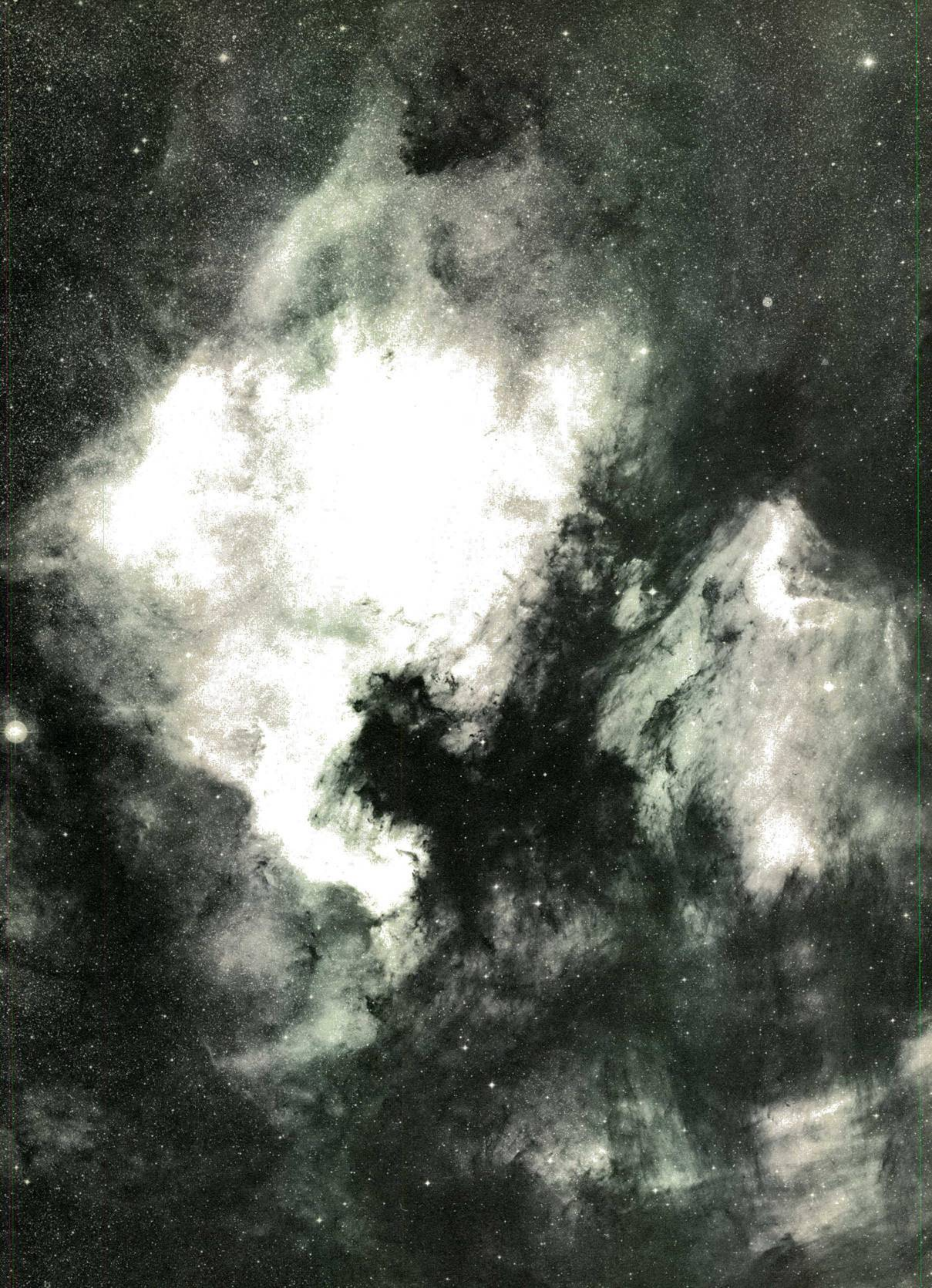


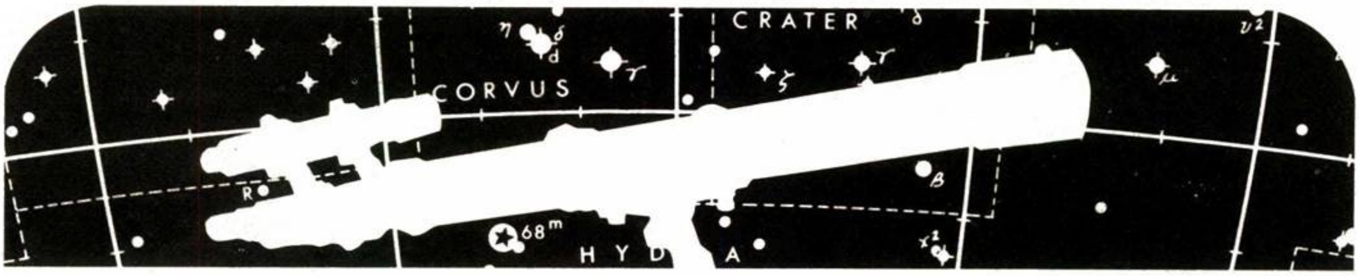
Finder scope and dial on a CELESTRON wedge aligning plate

This NEW easy-to-use concept in precision polar axis orientation lets you get perfect celestial pole alignment every time. The centered 4x erect cross hairs are set directly on Polaris. The 0.9-degree permanently offset rotatable 7/8" diameter barrel axis then lines up precisely on the true celestial pole position. A special simple chart and a 360-degree dial, supplied FREE, lets you select the correct position of Polaris with respect to the celestial pole for your photographic session on any night. This unique unit comes complete with brackets and can be mounted parallel to or inside your polar axis for any type scope.

Complete scope with dial and chart *$31.50*

Complete scope with dial, chart and the special CELESTRON 5 or 8 aligning plate *$58.50*





Schmidt Cameras

by
Robert Pike

The Schmidt camera is sometimes called the most useful research instrument in modern astronomy. The principle of its design was developed in the early 1930s by Bernhard Schmidt, a superb German optician who worked by hand — his left, as he lost his right arm in an accident with explosives when he was a child.

Schmidt's main interest was in designing an instrument free from the faults of paraboloidal mirrors; his design was elegant, simple and very effective. For the prototype instrument (a 14 inch f/1.7), he ground the primary and correcting plate in only a few 20 hour sessions. He tested it by taking photographs of the sky and the scenery around his workshop.

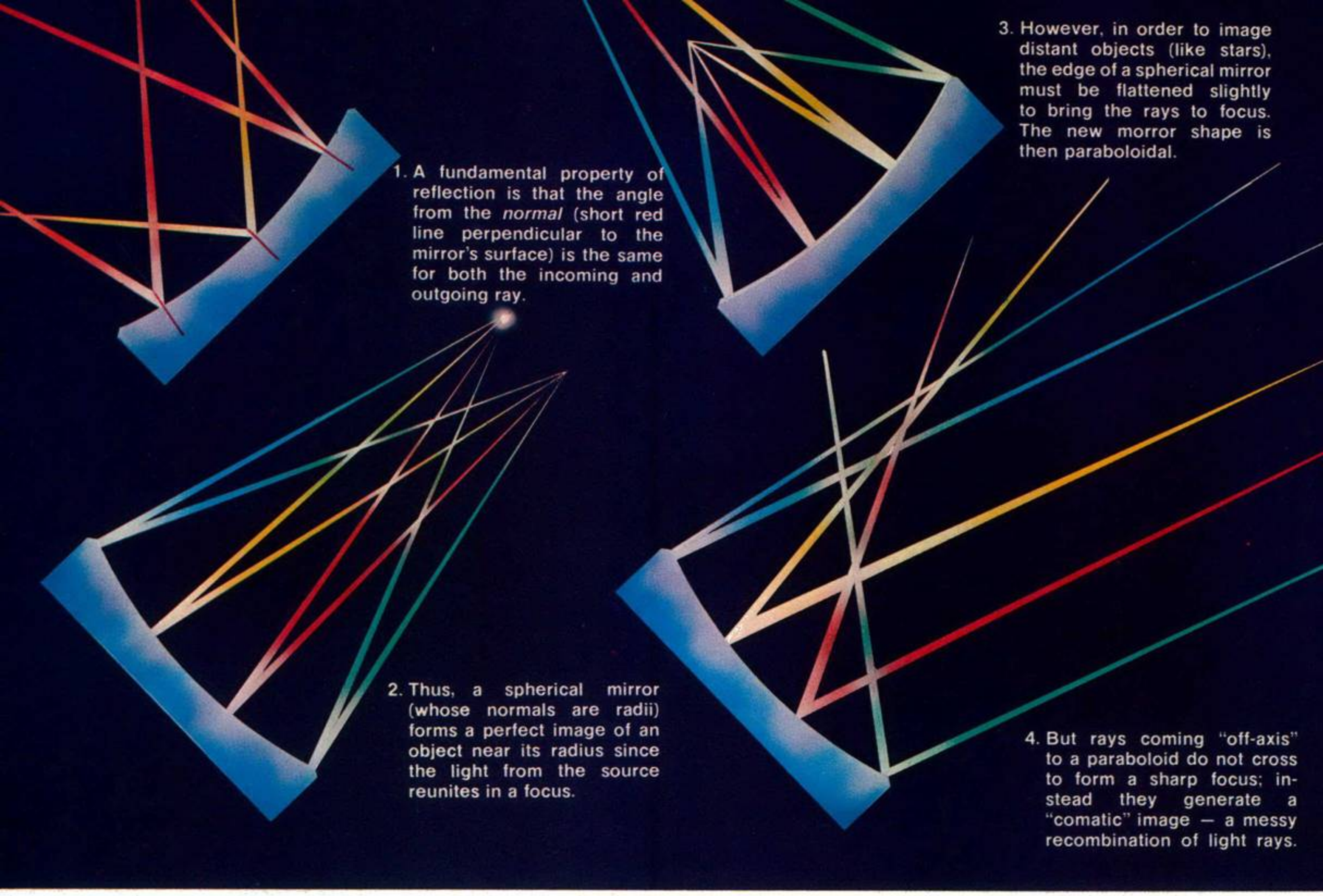
Although observatories around the world hailed the excellent photographs taken with Schmidt's prototype camera, it was several years before anyone would support the construction of a research-quality Schmidt telescope. The first was the 18 inch Palomar Schmidt, followed by the 48 inch Schmidt camera of Mount Palomar. Astronomy has been dramatically affected by the superb results from that instrument — particularly the Palomar Observatory Sky Survey.

Curious as it may seem, the primary mirror in a Schmidt camera is spherical, whereas most reflecting telescopes have paraboloidal mirrors. Beginning telescope makers often read that spherical mirrors don't form pointlike star images, and that telescope mirrors must be paraboloidal — the three-dimensional shape produced by spinning a two-dimensional parabola about its axis. Despite the spherical mirror — in fact, partly because of it — the Schmidt design is used in observatories throughout the world where photography is the prime observing activity. Resulting photographs are remarkably sharp, surpassing those of most other telescopes.

What is the reason for the excellent performance of the Schmidt telescope? The answer is the elegant principle of its design, which combines the useful optical properties of several shapes to produce near-perfect images across a very wide field of view.

In order to see the advantages of the Schmidt principle, examine a reflecting telescope and see what its faults are. When a ray of light strikes a reflecting surface, the reflected ray bounces off the mirror at the same angle as the incoming ray — but on the other side of a line called the *normal*, an imaginary line at right angles to the surface of the mirror. The Law of Reflection determines the optical properties of any reflecting surface, including curved surfaces. If the primary mirror of the telescope were spherical, light leaving the center of the sphere (of which the mirror is a section) would be traveling outward along a radius of the sphere; it would reflect back along the same line toward the center, because a radius of a sphere is at right angles to the surface at the end of the radius. But if the source of light is moved away from the sphere's center and toward "infinity", the sphere forms a poor image as the light does not all pass through a single point. You'll be able to see that all we need to do is alter the shape of the mirror a little to give a perfect image. Flattening the edge of the mirror just the right amount (to correct the image deficiencies) as the light source is moved away results in the focal point moving toward the mirror. The rays at the edge (which would not have reflected to the focal point) are re-

The precise image of a paraboloidal mirror and angular coverage of spherical concentric optics are combined in the Schmidt camera. The 48 inch Palomar Schmidt covers a glass plate 14 inches on a side, with near perfect images in a field six degrees on a side; small Schmidts can cover wider fields. The North America nebula was captured in a 40 minute exposure on 103aE at f/2.5, through a red filter. Photograph copyright© National Geographic-Palomar Sky Survey.



1. A fundamental property of reflection is that the angle from the *normal* (short red line perpendicular to the mirror's surface) is the same for both the incoming and outgoing ray.

2. Thus, a spherical mirror (whose normals are radii) forms a perfect image of an object near its radius since the light from the source reunites in a focus.

3. However, in order to image distant objects (like stars), the edge of a spherical mirror must be flattened slightly to bring the rays to focus. The new morror shape is then paraboloidal.

4. But rays coming "off-axis" to a paraboloid do not cross to form a sharp focus; instead they generate a "comatic" image — a messy recombination of light rays.

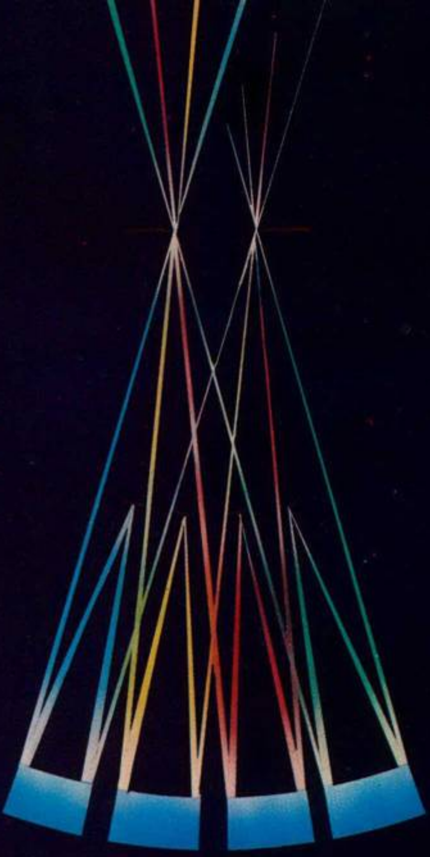
routed to the correct destination. Rays coming in parallel paths are a condition necessary in forming a stellar image in a telescope. The shape produced by deforming the sphere the right amount to produce a perfect image of a star is a paraboloid — the type of mirror most reflecting telescopes have.

It seems that the paraboloid is the ideal shape for a telescope mirror. But this is only true *when the rays are coming exactly down the middle of the telescope*, along a line called the *optical axis*. If the rays are not parallel to the optical axis (such as with a star off to the side of the telescope's field of view), the image has a lopsided appearance — an image fault called *coma*. Coma gets worse the farther off-axis the light rays are; it occurs because a paraboloid is not perfectly symmetrical. Rays coming toward the mirror at an angle do not meet the same mirror shape as those coming straight; thus, the image formed is not a point. The deviation off the optical axis need not be large — an angle of only five or ten minutes of arc produces small but noticeable deterioration of the images. More than a degree off the optical axis can cause images bad enough to be unusable: This is the fundamental fault of the paraboloidal reflector.

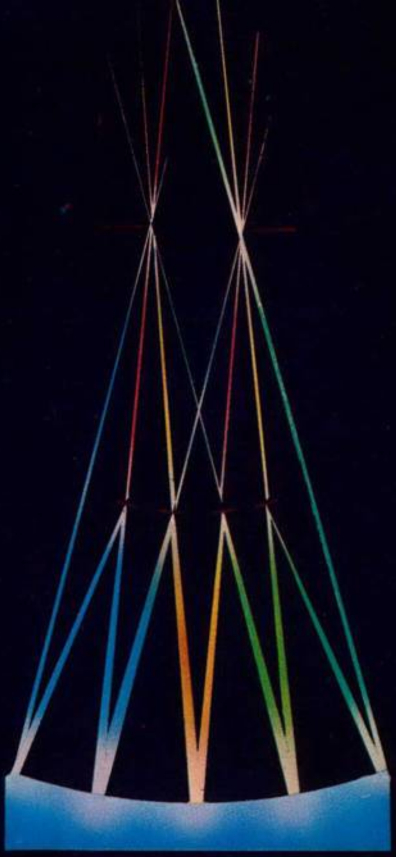
This problem does not occur in a sphere forming an image of an object at its center of curvature, because the shape of a sphere is the same no matter how we look at it. In combining the symmetry of the sphere and the accurate image formed by the paraboloid, there would be a wide field of good images. Since the paraboloid was formed by modifying a sphere, it seems reasonable to expect the advantages of both. One successful ingenious compromise is the Schmidt camera.

By mentally replacing the primary with a smaller paraboloidal mirror of the same focal length, you'll get an image the same size but dimmer. Because the mirror is smaller, the amount necessary to flatten the edge to produce a good image is less. If the mirror is small enough, the necessary correction to transform the sphere into a paraboloid becomes small enough to ignore completely. Thus, if the mirror is small enough, it can be made in a spherical shape. How small is small enough? For a six foot focal length, it's easy to get away with a six inch spherical mirror, which is a very powerful telescope! Now imagine a number of such telescopes with a special built-in instrument (see diagram). By pointing the telescopes in different directions so that each covers a different part of the sky, we could thus photograph a large part of the sky on one piece of film easily with a few simple telescopes. From the diagram, you'll see that the film must be *curved*. The images form on a section of a sphere with its radius equal to the focal length of the telescope.

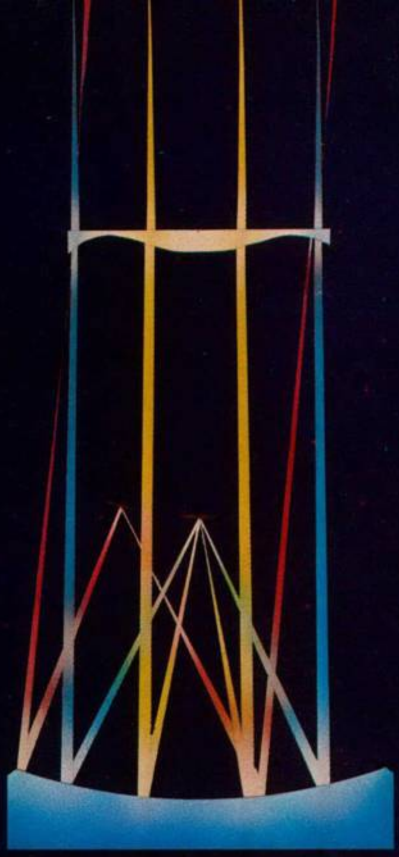
This rather strange looking instrument is fun-



5. By using lots of tiny paraboloidal mirrors arranged so that the incoming light crosses at their radii of curvature, we *can* form an image over a wide field.



6. In fact, we could replace the many small mirrors with one big spherical one. However, this arrangement doesn't collect much starlight.



7. But when we place a correcting lens at the radius of curvature (to make the main mirror behave like a paraboloidal mirror), the instrument covers a wide field of view and collects a lot of starlight.

Artwork by Mark Paternostro.

damentally like a Schmidt camera. All the mirrors are spherical; they have the same focal length and hence the same radius of curvature. The small mirrors can be replaced with one big 144 inch radius mirror, which will have the same 72 inch focal length as the small mirrors. Large spherical mirrors cannot produce good images, but by adding one extra part, a sharp image is formed. With an array of small instruments, all the light entering the telescope comes through a six inch diameter circle at the center of curvature of the mirrors (144 inches from them). So, to make the large spherical mirror work properly, place a six inch diameter diaphragm at the center of curvature.

This telescope design has one problem: In order to photograph the image from the mirror (which will be halfway between the diaphragm and the mirror itself), the film will block the light entering the system. You can compromise between the diaphragm size (which controls the quality of the images) and the size of the film (which controls the size of the field of view) to produce a useful, good quality image. Such a telescope is called a *lensless Schmidt*. They can produce good photographic quality images with an f/3 effective focal ratio. With these simple instruments, you can do better than you could with a paraboloid — but there is another refinement to make.

Schmidt reasoned that a properly shaped correcting lens placed where the diaphragm is would make it possible for the system to behave like a paraboloid mirror for the incoming rays. But once the rays passed the correcting plate, they would be at the center of curvature of the sphere, and produce a wide field image.

The *correcting lens* guarantees a wide field of near perfect images (a 20 degree field of view is not uncommon in Schmidt cameras). If you are mathematically inclined, you can determine what the exact shape of the correcting lens must be for it to perform its job of correction.

Since the Schmidt design was first developed, other instruments have been constructed which use a correcting plate to remove the image deficiencies of an optical element with some desirable property. Schmidt-Cassegrain telescopes make use of the correcting plate in another clever way: It's used to hold a secondary mirror to reflect the image out of a hole in the primary mirror.

The commercial Schmidt cameras available today sacrifice the wide-angle coverage of Schmidt cameras because they don't provide a large primary mirror to intercept the off-axis rays that pass through the corrector plate, nor a large enough film holder to catch the image that could be found. They do, however, offer beautiful, tiny images and very "fast" optics — a fine tribute to the one-armed German optician.

Announcing
Celestron® Binoculars

How do Celestron binoculars differ from garden-variety types available elsewhere? Mainly, they are built to stringent Celestron optical specs, and each binocular is individually tested and aligned on our laser collimator before shipment. In short, these are the first and only moderately priced glasses to meet our standards for true astronomical image quality. For star-gazing or general-purpose viewing, they invite comparison with binoculars two and three times their cost.

The Alternative You Can Trust

Celestron 11 x 80mm Giant Binoculars ▲

The most popular of the Celestron Binoculars. Under dark skies, they reveal dust lanes in the Andromeda Galaxy, present the Crab Nebula suspended like a pearl among its stellar companions and resolve such star clusters as M 35 and h & Chi Persei! Also fantastic for sports events.

Magnification	**11X**
Angular Field	**4.5°**
Linear Field	**235′ @ 1000 yds.**
Objective Diameter	**80mm**
Weight	**5.0 lbs.**

PRICE: $195 ppd. with tripod/monopod adaptor, lens caps, leather case with straps.

◄ Celestron 7 x 50mm Wide-Angle Binoculars

A superior system for low-light viewing — whether celestial or terrestrial — and yet extremely compact and light weight. View the Pleiades or the Orion Nebula in detail — but as if from a porthole in space. (And don't forget these glasses when you go to the races.)

Magnification	**7X**
Angular Field	**7.5°**
Linear Field	**393′ @ 1000 yds.**
Objective Diameter	**50mm**
Weight	**2.6 lbs.**

PRICE: $125 ppd. with lens caps, leather case and straps.

Alright, I'm convinced. If you put your name on these binoculars, they must be all you say they are. Here's my check for $________. Send me:

________ pair(s) of your 7 x 35's
________ pair(s) of your 7 x 50's
________ pair(s) of your 11 x 80's

Name ________________
Address ________________
City ________________
State ________________ Zip ________

Celestron

2835 Columbia St., Box 3578-AM
Torrance, California 90503, U.S.A.

Celestron 7 x 35mm Ultra-Wide-Angle Binoculars ►

Compactness, light weight and immense field of view make these binoculars a fine general-purpose glass. Frame entire constellations! Or see the star clouds of Sagittarius or Cygnus in their entirety! You won't believe your eyes — under dark skies, or at the twi-night double header.

Magnification	**7X**
Angular Field	**11°**
Linear Field	**576′ @ 1000 yds.**
Objective Diameter	**35mm**
Weight	**2.2 lbs.**

PRICE: $100 ppd. with lens caps, leather case and straps.

ASTRO-NEWS

Latest News From the World of Astronomy

Venus' Surface Geography Detailed in Radio Photos

Planetary scientists at the Arecibo Radar Observatory have released detailed radio "pictures" of the planet Venus showing a lava flow the size of Oklahoma, and large basins and ridges similar to those formed on Earth.

The pictures were obtained using the Arecibo Observatory of the National Astronomy and Ionosphere Center (NAIC) in Puerto Rico. (The observatory is operated by Cornell University under the sponsorship of the National Science Foundation.) Through a \$3 million contract with NASA, the 1,000 foot (330m) Arecibo antenna was upgraded to operate at centimeter wavelengths (in this case precisely 12.5cm), making it 50 times more sensitive than previous systems.

A second 100 foot (30m) antenna was constructed 6-1/2 miles north-northeast of the main reflector to form a receiving interferometer.

The system is predicted to have resolution capabilities of approximately 2.6 miles (4km) at the equatorial region, degrading slowly above 30 degrees latitude to about 12.4 miles (20km) at around 60 degrees latitude.

Data for the pictures were obtained in a series of daily two hour observing sessions during the months before and after August 1975, when the planet was in inferior conjunction. Most of the study was comprised of radar echoes of the 12.6cm signal from Sept. 7 and 10, as those two days seemed to yield highest quality data. Particular attention was given to the time, frequency and strength of the returning signal.

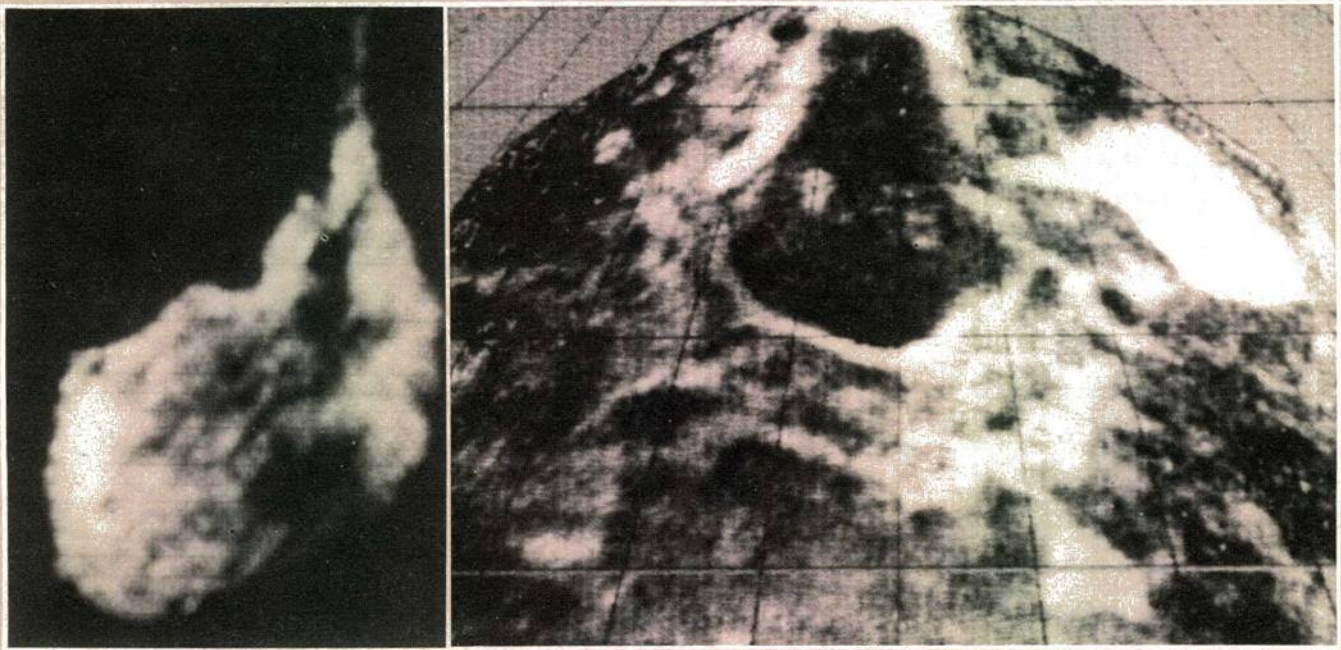
Observations were centered on an area from 46 to 75 degrees north latitude, and extending 80 degrees in longitude — for a total area of 4,000,000 square miles.

When Venus was previously examined with the low resolution 70cm radar at Arecibo, the high contrast area the size of Oklahoma was discovered and named Maxwell. Maxwell is thought to be a large lava flow, which may be indicative of the planet's internal processes. The area is highly reflective and seems to be covering an older surface. Structural forces are believed to have created the long parallel ridges which extend for hundreds of miles, in addition to the area's rough surface.

The other major region observed was a basin about the size of Hudson Bay — measuring approximately 1,000 miles (1,600km) by 600 miles (960km).

The north, northwest and south boundaries of the basin are comprised of bright, high contrast rims that appear like a series of sharp ridges several hundred miles long. A bright area south of the basin resembles the

Venus *continued on page 57*



NASA photographs

JPL Scientists Formulate Future Mission Proposals

Seven ideas for interplanetary missions have been formulated by a group of scientists and engineers at the Jet Propulsion Laboratory in Pasedena, Calif.

The ideas, which are still in the development stage, have all been classified under the title "Purple Pigeons — Bright Birds of the Future," according to a recent issue of **Aviation Week and Space Technology**. The seven mission subjects are as follows: the Martian land rover, the solar sail, the Venus radar mapper, the Saturn/Titan orbiter-lander, the Jupiter/Galilean satellites, the asteroid tour and the automated lunar base.

These areas were chosen for reasons of public as well as scientific appeal. Favorable public opinion may be needed in the upcoming budgetary battle.

The *Mars land rover* mission would be carried out by two small rovers that would be maintained by remote control. According to Clarence Gates, head of the planning force, "The aim of this mission is Mars exploration. We wanted something that would not be tied directly to the Viking mission, but we were convinced that any positive results from the Viking landers would lead to a desire for surface mobility."

A second alternative for the rover mission was to add two more rovers. The four rovers could cover from 621 to 932 miles (1,000 to 1,500km) in one Martian year (the equivalent of two Earth years).

The granular and textural composition of the Martian crust may be examined with x-ray and gamma ray spectroscopy in addition to multispectral imaging and optical microscopy. Other experiments could include alpha-particle back scattering, a mass spectrometer and an x-ray diffractometer. Payloads would be complementary to increase mission usefulness and flexibility. "They could perform a series of seismic operations, if one could thump the Martian surface while the other listens," Gates said.

The second of the seven possible missions is a *solar sail* to be used in conjunction with the visit of Halley's Comet in 1986. The sail would be 2,300 feet (700 meters) square and able to carry a 1,650 pound (750kg) payload. The direction and orientation of the sail would be controlled by 38 foot (10 meters) square movable vanes to be maneuvered differentially. Larger versions of the sail may be possible, extending it to about 6,560 feet (2,000 meters) square. Further research is needed on the material that will make up the sail, but the JPL group favors aluminized Kapton.

The sail's large, highly reflective surfaces are excellent receptors for the direct and reflected solar radiation which imparts force vectors on objects in space. The force vector results can be computed and used to drive the apparatus similar to the way a sailboat is powered by the wind.

Although the sail can carry payloads to and from planets, its primary mission is to rendezvous with Halley's Comet in March 1986, and to conduct experiments on it. Scientists have suggested separating the payload and sending it through the gaseous tail for analysis.

The *Venus radar mapper* is intended to "peel back the cloud layers around Venus and give us the first look at the planet's surface," Gates said. From a polar orbit, the entire surface of the planet would be mapped with a resolution of 1,312 feet (400 meters), with certain features being examined with the higher resolution of 164 feet (50 meters).

The proposed launch date is set for some time in the 1981-83 time slot as part of a Space Shuttle payload. An alternative would be launch by an Atlas-Centaur, in which case the planetary orbit would be elliptical rather than circular.

The fourth mission suggested is the *Saturn/Titan orbiter-lander.* The purpose of the mission is to put a lander on Titan to use it as a base to study Saturn. Little is known about the surface of Titan, which therefore complicates the design of the craft for survival purposes. Titan does have low mass and a dense atmosphere, two factors which may contribute to a soft landing. While the lander is conducting its studies, the orbiter will be performing long range studies of Saturn. If the spacecraft is launched by the shuttle in 1985, it should reach Saturn by 1990.

The *Jupiter/Galilean satellite* mission is one of planet formation as well as planetary studies. After a proposed February launch, the craft will orbit Jupiter using a gravity swingby of Ganymede. The gravitational forces of Callisto and Ganymede will be used to target the lander at Ganymede. After establishing direct communications with Earth, the lander will examine Jupiter's four major satellites (Io, Europa, Ganymede and Callisto) which appear to have been formed in a manner similar to that of planetary formation.

The planetary formation idea will also be studied on the *asteroid tour*. The mission is viewed from the aspect of evolution, assuming that asteroids are remains of the acretion phase of the solar system. Possible instruments on board could resolve images less than 328 feet (100 meters). Other activities include multispectral measurements, mass measurements and magnetic surveys.

The spacecraft could be launched by conventional methods in the early 1980s. But a conventional launch would result in a ballistic trajectory that would pass too close to the asteroids to do any good. In order to prevent the images from being smeared, the spacecraft would have to travel at speeds of .6 miles per second (1km per second). A second possibility, the solar sail, would satisfy the speed requirements but would push the earliest launch date back to 1984.

The last idea concerns an *automated lunar base*. The base would evolve through four stages: polar orbit survey, rover samples of oxygen and water, processing lunar soil of volatile materials and setting up the station for manned purposes.

In the first stage, the polar orbiter would perform a geochemical and gravitational analysis of the moon. It would also make an attempt to locate lunar minerals.

The second and third stages involve landing the automated lunar base near the south pole. Surface samples that might contain water or oxygen will be gathered by the lunar rover and a solar powered processor will be set up to remove volatiles from the lunar soil.

The fourth stage would land support facilities, including two return vehicles which would be followed by a crew of scientists to operate the station.

The tentative mission list will be sent through the Mission Analysis Division at JPL, and then forwarded to NASA headquarters.

Stability of Physical Constants Questioned

Ever since the discovery that the universe is expanding, one of the basic questions of physics is whether its fundamental constants change with time as the universe evolves. Recent work suggests that, to a very high degree of precision, they remain stable.

This conclusion was reached by a team of astronomers led by Morton Roberts of the National Radio Astronomy Observatory. Robert's group succeeded in measuring the redshift of the 21cm hydrogen emission associated with a radio source several billion light-years distant. This particular source, identified by its catalog number as AO 0235+164, is a BL Lacerta type object for which an optical redshift already exists.

E. Margaret Burbridge and her collaborators had obtained a redshift of 0.52392 based on the spectral lines arising from magnesium ions. The radio frequency redshift agrees with this figure to four decimal places. If we assume that the Hubble law relating distance and redshift is applicable, then the distance of AO 0235+ 164 implies we are looking back in time more than 1/3 the age of the universe.

Roberts and his group took the physical theories that explain these spectral lines and formed a ratio which involves several fundamental quantities: the constant which characterizes electromagnetic phenomena (the fine structure constant), another which relates the mechanical and magnetic energy of the proton, and thirdly the ratio of the electron and proton masses. The value of this overall ratio derived from the redshifted lines, which were formed several billion years ago, agrees with the current value so precisely that these quantities could not have changed by more than one part in 10,000 during the intervening eons.

Giant Windmill Tested As Energy Alternative

Solutions to the energy problem have been wide and varied, ranging from the conventional use of coal to the unconventional method of using gas from garbage. The newest idea being tested is the building of the world's largest windmill. The project is being sponsored by the Energy Research and Development Administration and NASA.

The system is designed to test the operational and economic feasibility of combining conventional power and windmill plants. Most of its $7 million cost will be used for the design and engineering of the wind turbine electrical generating system which should be operational by 1980.

Although primarily an experimental project, the 1.5 megawatt windmill will be located near a utility company site so the power will be available for public use.

The windmill — the largest ever built — will have rotor blades spanning 200 feet (73m), rotating on a 150 foot (55m) tower. At maximum power output with winds of 22 m.p.h., the blades will be rotating at 60 to 80 revolutions per minute. At a site with average winds of 18 m.p.h., the windmill will be able to supply energy for 500 homes annually.

Venus *continued from page 55*

ejecta blankets surrounding some lunar craters, indicating there may be similarities between the forces which formed the moon's maria and Venusian forces. There is also a feature which resembles two small impact craters inside the basin area.

According to the scientists, Maxwell and the high contrast areas appear to be the result of tectonic activity on the planet. The impact theory seems rather weak when viewed in the light of the known, well-defined boundaries, surface roughness and irregular shapes. However, with the exception of the northern rim which could have been altered at some time, the scientists say the basin does have the general characteristics of an impact crater. Further study of the area at higher resolutions will be necessary to definitively answer this question.

BRIEFS

●Jamming of signals by potential enemies may be reduced through usage of a new Jammer Reduction Antenna (JARED). The antenna will attempt to blind signals that are aimed at satellites of the Defense Satellite Communication System Phase II (DSCS II). JARED is being tested for use on the DSCS II.

●Venus will be the target of both an orbiter and a four-probe spacecraft in 1978. The probes, aimed at four different areas, will relay data on the planet's atmosphere and weather, wind and circulation patterns.

●Research on the use of alternate energy sources has begun to hit closer to home. Scientists are planning to study the feasibility of a solar powered refrigerator.

NASA and the Energy Research Development Administration have joined together to study the refrigerator as part of their Photovoltaic Test and Demonstration Project. This will be yet another example of how solar cells can be used for everyday applications.

●Facilities and equipment on board Spacelab will be comparable to their Earth counterparts, but will be adapted for operation in the gravity-free weightlessness of space.

●NASA researchers are considering the possibility of hanging a tethered probe from the Space Shuttle to study gravitational effects and the magnetic field, and to increase the accuracy of aerodynamic and temperature studies.

The probe would hang 62 miles below the shuttle, and would conduct observations at altitudes ranging from 50 to 75 miles above Earth.

●Satellites have been designed to transmit medical information from moving ambulances to the hospital. The system was developed by engineers and scientists at NASA's National Space Technology Laboratories.

ASTRO-MART

Looking for an "astro-thing"? Want to trade in your old scope for the latest model? Got something to sell? Then let the world know with a free ad in Astro-Mart. As an ASTRONOMY subscriber you are entitled to two free classified ads in this department each year. So take advantage of this unique, service; send in your free Astro-Mart ad today!

Lightweight Brick Adapted For Space Shuttle Use

In its efforts to produce the Space Shuttle, the scientific community has put "the cart before the horse" in developing a material to coat the shuttle's surface.

According to a recent article in **The New York Times**, the resultant brick, developed by Lockheed Missiles and Space Co., is a kind of frozen glass souffle with black or white coatings. The ultralight material has a density of nine pounds per cubic foot.

The **Times** reported that the brick will be up to five inches thick and will cover 70 percent of the shuttle's surface. Each time the shuttle returns to Earth, the brick coating will be heated to temperatures between 600 and 2,300 degrees Fahrenheit. The nose and forward wing portions of the craft that are exposed to higher temperatures (approximately 3,000 degrees Fahrenheit) will be composed of structures of pure carbon manufactured by LTV Aerospace Corp. of Dallas, Tex.

Originally, each of the 24,000 bricks for each shuttle was to be ground to the exact contour of the aluminum surface to save on weight and allow for heavier payloads. Each unique tile was then to be applied by hand to the craft. Instead, Lockheed has eliminated costly hand labor by substituting a group of more than 1,200 vacuum operated metal frames to put the bricks into 20 piece sections that will be applied together.

In designing the brick for shuttle use, a new method was developed to coat each of the microfibers and microspheres with a waterproofing material. This process was necessary to prevent the humid Florida air from permeating the craft and adding tons of extra weight to it while the craft is waiting to be serviced.

While the brick is a great boon to the shuttle program, it was originally developed because Lockheed was seeking a contract to build a communications radome for the Apollo moon capsule.

Advertise it free in Astro-Mart.

Japanese Firm Features New Color Film With Faster ASA

Fuji Photo Film Co. of Japan announced in early September that it would be marketing a new ASA 400 color film in that country beginning in October. Export sales to the United States are set for late November or early December.

The film will be a relative boon for astrophotographers, who usually have had to settle for the much slower ASA 80 rating of conventional print films. The standard method of getting around this was to use a high speed ASA 160 slide film, and to "push" it through a special process to ratings of 400, 800 and 1600. The new film will allow for shorter time exposures, thus leaving a smaller margin for error.

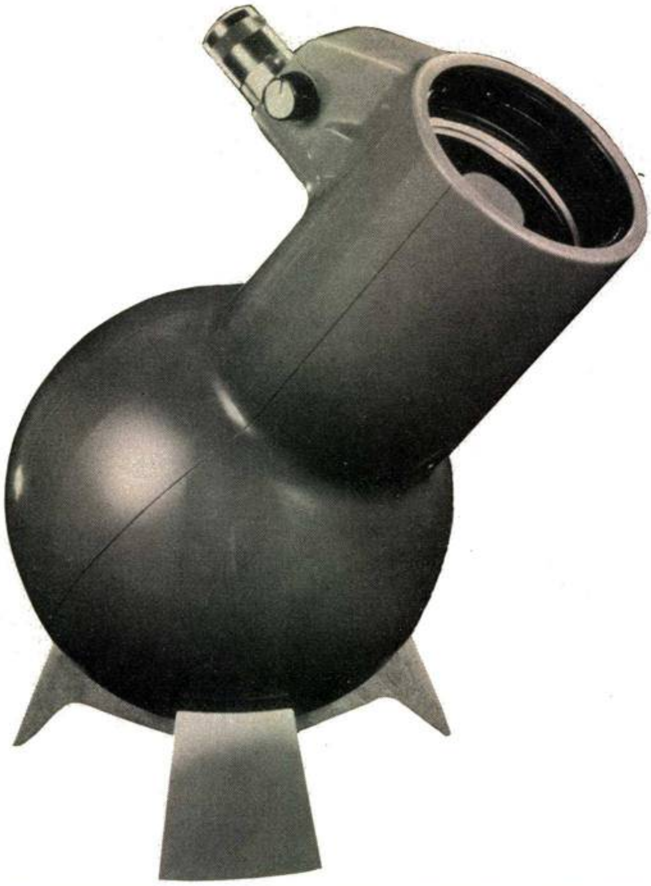
In a telephone interview with the **Wall Street Journal**, Tomio Saito, a resident analyst with Baker, Weeks and Co. of Tokyo, said that Fuji is expected to produce two to three million 20 exposure rolls per month, and may eventually produce the film in the 100 size used by most amateur photographers.

According to the **Wall Street Journal**, amateurs using simpler cameras and film in the 110 and 126 sizes dominate the U.S. market. Latest industry statistics showed 16 million 35mm cameras in use in 1974 and 42 million in the 110 and 126 sizes. Analysts attribute about 21 percent of the U.S. market to 35mm film.

Shozo Takekoshi, director of corporate planning for Fuji Photo Film USA, confirmed that the parent company "will be considering the 110 film format in the future". However, ASA 400 film in this category probably won't be made until more cameras are available to handle the film speed. Most simple cameras don't currently have lenses capable of using such a fast film, Takekoshi said.

With regard to processing, Takekoshi said the new film is compatible with the current process used to develop Kodak film and produce color negatives. The film is expected to cost approximately 20 percent more than existing color film.

"I KEEP PICKING UP CB CALLS."



WHATSITSNAME, the completely unique new Edmund 4¼" Newtonian Richest Field Reflector Telescope. Clearest, brightest, most spectacular wide angle views of moon, stars, comets, galaxies you've ever seen. Here are just a few of its outstanding features:

Compact, portable, sets up in seconds. It's pre-collimated and ready to use. Just pop in the eyepiece, focus . . . and presto! Its fantastic 3½° field of view gives you more stars in a single view than any other type telescope . . . bright, crisp, finely resolved images. For sky gazing and earth gazing too!

Take it anywhere! Only 17", 10 pounds. Easiest-to-use telescope ever! Over your shoulder, in your lap, on a tripod. Or just rotate the spherical base on its own aluminum mount for use on a table, car hood, etc.

Maintenance-free, top quality optical system features 4¼", f/4 parabolic primary mirror (1/8 wave, 17" F.L.); pre-aligned 1/8 wave diagonal is right on coated optical window that seals optics from moisture and dust; standard 28mm Kellner eyepiece (gives 15X, higher with other eyepiece or Barlow).

Beautiful, colorful, sleek and modern! A real conversation piece and a joy to own and use. Rugged high impact plastic body, bright Scharfanian red (doesn't impair night vision); fast, posi-grip roller focusing (25' to infinity); adjustable carrying strap and much more! The telescope of the future, here today.

Stock No. 2001K .... Special Introductory Price $129.95 Ppd.
(Goes to $149.95 Dec. 25, 1976)

CONTEST RULES AND REGULATIONS

1. No purchase required to enter. **2.** All entries must be received by Edmund Scientific Co. no later than November 15, 1976, and become the sole property of Edmund Scientific Co. **3.** An official entry form, or reasonable facsimile, should be used for each entry. **4.** Entries will be judged on originality and practicality. **5.** Decision of the judges will be final. **6.** In case of ties, winning entry will be the one with the earliest postmark. **7.** Winners will be notified by mail, and their photos and names will appear with the announcement in the next issue of the nationally distributed Edmund catalog. **8.** This contest is void where prohibited by law. **9.** "Name the Telescope" contest is not open to employees of Edmund Scientific Co., its advertising agency, this magazine or any judge of this contest. **10.** Every entrant, whether a winner or not, will receive FREE a 1-year subscription to "Astronomy News".

EDMUND SCIENTIFIC CO.,
300 EDSCORP BLDG.,
BARRINGTON, NJ 08007 (609) 547-3488

A star is born . . . name it, win it!

(in time for Christmas!)

GRAND PRIZE: TWO NEW EDMUND PORTABLE RICHEST FIELD 4¼" f/4 NEWTONIAN TELESCOPES, INTRODUCTORY-PRICED AT $129.95 EACH.
(One for you, one for the school or planetarium of your choice.)

PLUS $500 CASH BONUS YOURS IF YOU BUY* ONE BEFORE YOU WIN TWO!

2nd PRIZE $100 CASH
3rd, 4th, 5th PRIZES—$50 EDMUND MDSE. CERTIFICATES

EVERYBODY WINS! ALL ENTRANTS GET A *FREE* 1-YEAR SUBSCRIPTION TO "ASTRONOMY NEWS" (a $5.00 value). 12 fact-filled issues packed with the latest astronomical news and discoveries.

* Special introductory price valid for all orders received by midnight December 24, 1976 . . . when it goes to $149.95. If you're the Grand Prize Winner, we'll refund your $129.95.

Get in the contest—it's easy, fun, creative and rewarding! Just read the description under WHATSITSNAME'S illustration for information and inspiration—then, write your suggested name for Edmund's new telescope on the entry blank below, fill in and mail. Your brainchild may be the winner! So, give it a go—lots of good hints in that fact-filled paragraph above WHATSITSNAME'S introductory low price. No purchase necessary to enter, and here's more good news. If you buy the new 'scope now (why *wait* to enjoy it . . . why not own it now, or give it for Christmas at the special introductory price?) and you do become the Grand Prize Winner, we'll refund your $129.95! *Plus* . . . you'll get a $500.00 Cash Bonus buyer's prize. Okay? Name the telescope!

ALL ENTRIES MUST BE RECEIVED BY NOVEMBER 15, 1976!
USE THE OFFICIAL ENTRY FORM/ORDER FORM BELOW, OR REASONABLE FACSIMILE. ONE NAME PER FORM. USE IT ALSO TO ORDER EDMUND'S NEW 'SCOPE NOW AND SAVE $20.00. NO PURCHASE NECESSARY TO WIN—AND IF YOU WIN, YOU'LL GET YOUR $129.95 BACK!
If form is missing, send your entry and/or order on separate piece of paper (one entry per sheet) to:

CONTEST"K"
EDMUND SCIENTIFIC CO.
300 EDSCORP BLDG.
BARRINGTON, NJ 08007

Be sure to include your Name, Address, City, State, Zip.

OFFICIAL ENTRY/ORDER FORM—MAIL TODAY!

Contest"K"
Edmund Scientific Co.,
300 Edscorp Bldg., Barrington, NJ 08007

☐ Send FREE 164-Page Catalog K

Charge my
☐ American Express
☐ BankAmericard
☐ Master Charge
Interbank No. ______
Card No. ______
Expiration Date ______

☐ Yes, I'm ordering the new telescope now and saving $20.00. Send me: ____ "WHATSITSNAME", PORTABLE TELESCOPE(S) NO. 2001K at Special Introductory Price of $129.95 ea. $______
Service & Handling Charge $ 1.00
Enclosed is ☐ Check ☐ M.O.
For TOTAL of $______

30-DAY MONEY-BACK GUARANTEE. You must be satisfied or return any purchase in 30 days for full refund.

Signature ______
Name ______
(Please Print)
Address ______
City ______ State ______ Zip ______

☐ No, I'm not ordering the new telescope now, but here's my contest entry. My entry for the name of the telescope is:

______
(Please Print)

FOR YOU...

THE OPPORTUNITY TO OBTAIN THE MOST ADVANCED Celestron 8 telescope, with **Digital Readout Setting Circles** already installed, for the fantastically low package price of $995.00.

If you have wanted a Celestron 8 now is the time to stop hesitating. Write to S & S Optika, Ltd. for details. If you wish immediate delivery just phone (303) 789-1089.

On all orders received by Dec. 1, shipping will occur prior to Dec. 5 so Christmas delivery is certain.

If you own a Celestron telescope, don't forget to write for data about getting the setting circles for your own telescope. A perfect gift idea.

S & S Optika, Ltd. proudly announces a new product. **Digi-Guide™ Ultra Linear Drive Module.** This NASA specification variable frequency power supply operates from 12 volt car battery or 110 volt line current. This unit is so advanced in its many features that we invite your inquiry so we can send you the complete story. It is priced at less than $110.00!

Everything available for Christmas delivery.

S&S Optika, Ltd.
3853 South Broadway
Englewood, Colorado 80110
Phone (303) 789-1089

ASTRONOMY

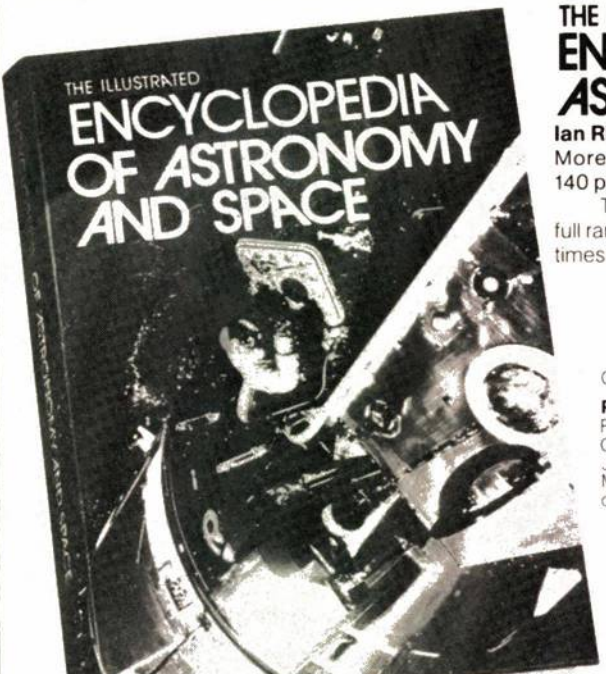
Index to Volume 3, 1975

ASTRONOMY's cumulative Index to Volume 3, 1975 is now available. This subject index covers the months of January through December 1975 which includes issue Nos. 1 through 12. Index to Volume 3 is available for $1.25 each, plus .25¢ per order for first class postage and handling.

Order your indexes today!

ASTRONOMY 411 E. Mason, Sixth Floor, Milwaukee, WI 53202

THE MOST UP-TO-THE-MINUTE SPACE PROBE NEXT TO VIKING



$16.95
Library of Science
Book Club Alternate

THE ILLUSTRATED
ENCYCLOPEDIA OF ASTRONOMY AND SPACE

Ian Ridpath, General Editor

More than 1,000 entries illustrated with more than 140 photos in full color and black and white.

This is the most up-to-date and complete volume reference, covering the full range of astronomical knowledge and space exploration from ancient times to the present. Includes everything from:

- Astrophysics to X-Ray Astronomy
- Black Hole to Red Shift
- Big Bang to Steady State
- Eratosthenes to Einstein
- Cepheid to White Dwarf
- Asteroid to Uranus
- Armstrong to Gagarin
- Apollo to Zond

Other Pictorial Guides on Astronomy available from Crowell...

Pictorial Astronomy
Fourth Revised Edition by Dinsmore Alter, Clarence H. Cleminshaw, and John G. Phillips
More than 300 photographs, maps, drawings, and diagrams $12.50

Pictorial Guide to Planet Earth
by Frederick I. Ordway, III More than 150 photos, 16 pages in full color $12.95

The Amateur Astronomer's Handbook
Revised and Expanded Edition
by James Muirden More than 80 photos and line drawings $9.95

At your bookstore or direct from:
T.Y. CROWELL c/o Conklin Book Center, Inc. Dept. MT-A
P.O. Box 5555, Binghamton, New York 13902
Please send me
______ copies of **The Illustrated Encyclopedia of Astronomy and Space** @ $16.95 ea.
______ copies of **Pictorial Astronomy** @ $12.50 ea.
______ copies of **Pictorial Guide to Planet Earth** @ $12.95 ea.
______ copies of **The Amateur Astronomer's Handbook** @ $9.95 ea.
I enclose ☐ check ☐ money order for $______ total. (Please add applicable sales tax.)
Name ______
Address ______
City ______ State ______ Zip ______

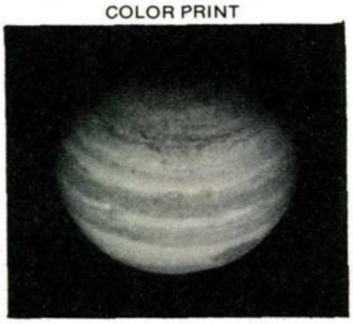
ASTRO-MART

Astro-Mart is a free, reader service department available only to current, paid, noncommercial subscribers; 2 ads are allowed per year. Each ad submitted must not exceed 40 words in length (including name, address, etc.). All ads are subject to editorial review for suitability. Be sure to allow 3-4 months for your ad to appear.

astro murals

24" x 36" photo-quality prints of plates from world's great observatories. Heavy matte paper. All postpaid.

COLOR PRINT



C-8 North Pole of Jupiter from Pioneer 11

13 black and white and 6 color prints available.

WRITE FOR BROCHURE

Black-and-white Astro-Murals	$7.50 each
Color Astro-Murals	$18.00 each

astro-murals
box 7563-A
Washington, D.C. 20044
703-280-5216

Wisconsin's Most Complete Telescope Display

CELESTRON
5" and 8"
UNITRON
Complete Line
TASCO
Complete Line
Most Orders Filled From Inventory
Inquiries Welcome

WACK
Electronics Inc.
5722 W. North Ave. Dept. AM.
Milwaukee, Wis. 53208
(414) 442-3441

BankAmericard Master Charge
90 Day Financing Available

ASTROFILMS IN 36-exp 35mm ROLLS

Now obtain the most popular films for Astrophotography

- Spectroscopic with antihalation rem-jet backing
  Order 103aF, 103aE, or 103aO **$6.25 ea.**
  3 or more (any combination) **$5.50 ea.**
- SO-410 (planets, moon, sun) **$2.20 ea.**
- High Contrast Copy (planets, full moon, sun) **$2.20 ea.**
- 2475 Recording ASA 3200 at short exposures **$2.70 ea.**

Film information included with order, 35¢ separately

ASTROFILM
P.O. Box 2731, Dept. AM
Akron, OH 44301

OPTICAL DESIGN SERVICE

Institutional and Commercial

R.A. Buchroeder
7270 E. 19th St., Dept. AM,
Tucson, Ariz. 85710
Phone: (602) 885-1793

ASTRONOMY MATERIALS

TELESCOPES, 35mm SLIDES, ASTRO GLOBES, SKY CHARTS, BOOKS, PHOTOGRAPHS, MURALS, AUDIO-VISUAL, BINOCULARS, PARTS FROM AMATEUR TELESCOPE MAKERS & MUCH, MUCH MORE!! Your one source for Astronomy Materials. Unique catalog includes discounts on TASCO optical goods. Write for yours today. Enclose 52¢ stamps stating area of interest. MMI Corporation, Dept. A, 3016 Cresmont Ave., Baltimore, Md. 21211 (301) 366-1222.

LATITUDE ADJUSTER
For Celestron 5 & 8 wedges

Now you can have perfect polar alignment with ease. Steel for strength. Installs without tools. A must for astrophotographers.

$12.00

David A. Potter
723 Cedar, Dept. A, Sandwich, IL 60548
(815) 786-8168

OPTICAL COATING

ALUMINUM WITH HARD OVERCOAT

Size	Price
Up To 6"	$11.00
Larger Than 6"	$16.00
Larger Than 9"	$22.00
Larger Than 13" To 16"	$40.00

Add return postage and insurance. Gold and silver coating Also available.

HELIO ASSOCIATES, INC.
A Division of
Mountain States Mineral Enterprises.
P. O. BOX 17960. TUCSON, AZ 85731
Phone 602-792-2800

FOR SALE — Back issues of ASTRONOMY: January 1975 to present. Best offer. Write M.L. Gerken, 419 Maple Blvd., Kansas City, MO 64124.

FOR SALE — University Optics 12 x 40 finderscope with brackets. Never used; in original box. Price: $21.50. Write Dave Howard, 324 S. Weitzel, Apt. Q, Oceanside, CA 92054.

CELESTRON TELESCOPES ON DISPLAY AND IN STOCK

E & W OPTICAL, INC.
2420 EAST HENNEPIN AVE.
DEPT. AM
MINNEAPOLIS, MINN. 55413
612-331-1187

SEND FOR PRICE LIST "A"— Astronomy supplies and accessories.

AMATEUR RADIO ASTRONOMER'S NOTEBOOK
$20.00 POSTPAID IN U.S.A.

Prepared by successful amateurs for amateurs 96 page projects manual contains assembly plans for

- Pen recorders and data reduction
- Simple solar noise storm receivers
- Antenna and preamplifier construction
- Jupiter noise storm receiver
- High resolution 32 to 64 cm interferometer

Emphasis is on maximum performance and ease of construction with readily obtainable parts and assemblies

FREE WITH ORDER. CASSETTE TAPE OF RADIO NOISES OF 6 PULSARS, JUPITER, AND A TYPE III SOLAR BURST

BOB'S ELECTRONIC SERVICE
817 NORTH ANDREWS AVE. FORT LAUDERDALE, FLA. 33311

BUILD YOUR OWN 10' OBSERVATORY FOR UNDER $250

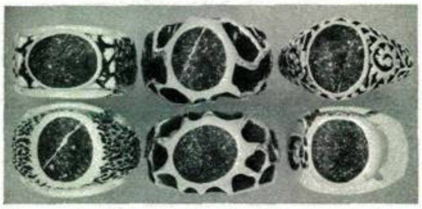
COMPLETE PLANS ARE NOW AVAILABLE FOR A PLYWOOD AND MASONITE DOME WITH CYLINDRICAL BASE. INCLUDED IN EASY-TO-FOLLOW INSTRUCTIONS ARE:

— **UNIQUE SHUTTER DESIGN**
— **NEW, EASY METHOD OF CUTTING DOME RIBS**
— **PICTURES OF FINISHED OBSERVATORY**

SEND ONLY $10.00 (IOWA RESIDENTS ADD 3% SALES TAX) **CALL OR WRITE: JEFF SCOTT**
TWIN CAVES OBSERVATORY 204 S. PARK LANE DR.
DEPT. AM KNOXVILLE, IOWA 50138 (515-842-4847)

METEORITE RINGS

Now in 14Kt. Gold or Sterling Silver



The only rings on Earth with stones from outer space. Only $28.50 in sterling silver or $85.50 in 14kt. gold. For free brochure write: **HOUSE OF RINGS**

P.O. Box 6127, Dept. AM,
Kansas City, MO 64110
Phone: 816-363-2002

FOR SALE — Cave 6" f/6 tube assembly, 50mm finder, Carle photo-visual focuser with collimation cap, fiberglass tube, no eyepieces. 6 months old. Price: $130.00. Write Robert Ficara, 2 Turkey Hill Rd., Newington, CT 06111.

FOR SALE — Back issues of ASTRONOMY and other astronomy and science fiction magazines. Send SASE for details to J. Jacobson, 639 Hill St. - #D, Santa Monica, CA 90405.

FOR SALE — Miranda - F 35mm camera, f/1.9 lens; $60.00. Vivitar 400mm preset lens, $40.00. Soligor 28mm preset lens, $25.00. Off-axis guiding system for Celestron 8; $70.00. Contact Stan Lopata, Box 246, West Lebanon, NH 03784. Phone (603) 448-2509.

FOR SALE — Hewlett-Packard application pacs for HP-65 calculator: math 1, statistics 1, local sidereal time, atmospheric extinction, sky brightness, satellite co-ordinates, etc. Price: $60.00. Contact Richard Lorber, 20715 Roscoe Blvd., Canoga Park, CA 91306. Phone (213) 882-3265.

FOR SALE — Yashica J-7 SLR camera body and f/1.4, 50mm lens. Perfect for astrophotgraphy. Price: $100.00. Contact P. McGuire, 2320 Carnegie Ln. - #B, Redondo Beach, CA 90278. Phone (213) 376-6091.

FOR SALE — Binoculars with cases. Tasco 7 x 35, 12-1/2° field; excellent; new, $110.00. Price: $55.00. Binolux 7 x 35, 12-1/2° field; $42.00. Zeiss Jenamint 7 x 50; $225.00. Write William Mecca, 1527 Madison Ave., Dunmore, PA 18512.

FOR SALE — 4" Unitron, equatorial mount, electric drive, Unihex, Duetron, model 220 astrocamera, 7 eyepieces, tripod, additional accessories. All in excellent condition. Price: $1,000.00. Contact Curt Mettlin, 4200 Main St., Buffalo, NY 14226. Phone (716) 838-4216.

FOR SALE — All back issues of ASTRONOMY through July 1976. Mint condition except cover damage on August 1974. Price: $120.00. Contact Robert W. Moell, 5505 Daywood Ct., Raleigh, NC 27609. Phone (919) 782-2487.

FOR SALE — 3.1" refractor with equatorial mount, many accessories. Excellent condition; worth $470.00. Asking $270.00. Contact Robert Moheit, 5428 Oakbank Dr., Covina, CA 91722. Phone (213) 332-4589.

FOR SALE — 3" equatorial refractor, 7 oculars (2 orthoscopic), all accessories. Like new. Must sell; buying bigger scope. Price: $175.00. Write Mike Petrozello, 329 Brooksboro Dr., Webster, NY 14580.

FOR SALE — Unitron 4" altazimuth refractor, super Unihex, super rack and pinion, sun projection screen, etc. Excellent condition. Price: $400.00 plus shipping (will deliver in Florida). Write H.G. Schmoock, 3901 Edgewater Dr., Orlando, FL 32804.

FOR SALE — 12-1/2" f/5 Newtonian reflector, 7 x 50 finder, eyepieces, equatorial clock drive, 2.4" refracting guidescope, massive mount. Never used; mint condition. Price: $595.00. Contact James R. Sloan, 4 Admiral Dr., #427, Emeryville, CA 94608. Phone (415) 653-2958.

SKYWATCHER'S ALMANAC 1977

A COMPUTER–GENERATED CALENDAR that provides

- Sunrise, sunset, moonrise, & moonset times, and phases, specifically computed for your latitude and longitude
- Planetary phenomena and visibility
- Constellation data, visibility, diagrams
- Navigation star data, and other useful information

In use by schools, newspapers, planetariums, amateurs and professionals alike. $9.00 U.S. currency, post-paid. Foreign orders specify geographical coordinates. California add sales tax.

ASTRONOMICAL DATA SERVICE

1901 Old Middlefield, Suite 14B
Mountain View, California 94043

CELESTRON DEMONSTRATIONS

Under Night (or Day) Skies

Need help in selecting a scope? Or choosing a system? Want to see before you buy?

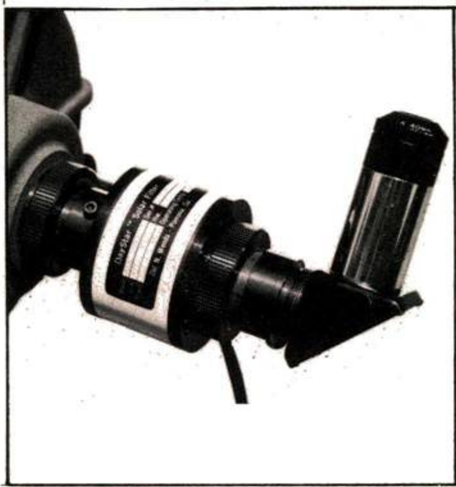
We will demonstrate the Celestron system (or any of the fine products listed below) and help you choose just the right components for your visual and photographic needs. Celestron 5, 8, binoculars and all standard accessories are kept in stock along with a selection of other quality products, books, and atlases.

Decided what you want? Phone and mail orders are accepted.

David A. Potter
723 Cedar, Dept. A, Sandwich, IL 60548
(815) 786-8168

master charge

Dealer For:
Astro-Physics telescope controls
Celestron telescopes & accessories
Del N. Woods DayStar filters
DOAA drive correctors & PLS camera
University Optics oculars & mounts
Vernonscope oculars



DayStar Filters

***Hydrogen Alpha**
***Calcium K-line**
***Corona filters**
***Laser line filters**
***Half-bandwidths:**
0.4 Å to 100 Å
***Wavelength range:**
3700 Å thru 2.5 u

DEL N. WOODS
P.O. Box 1290, Dept. AM,
Pomona, CA. 91766
Phone: 714/629-0600 (N.Y.) 914/786-3738

"Superb! It's a whole new adventure . . .

"My knowledge has been increased tenfold since I started your course. I'd recommend it to anyone! Thank you, Coast Navigation School!"
Barry Fellinger, Niagara Falls, Ontario

Let us help you begin a whole new adventure with our two fascinating home study courses designed especially for amateur astronomers. Call or write today for our free course catalog.

CELESTRON Schmidt-Cassegrain and UNITRON Refractor telescopes available.
Special prices on course/telescope combinations.

Coast Navigation School of Astronomy
Dept. 5330 418 E. Canon Perdido
Santa Barbara, CA 93102 / 805 963-7837

I'm interested! Please send me your free school catalog.

Name
Address
City
State, Zip

THE OPTICAL CRAFTSMEN INC

TELESCOPES

4¼" PRO 425 $149.50

TELESCOPES

8" DISCOVERER $555 up

TELESCOPES

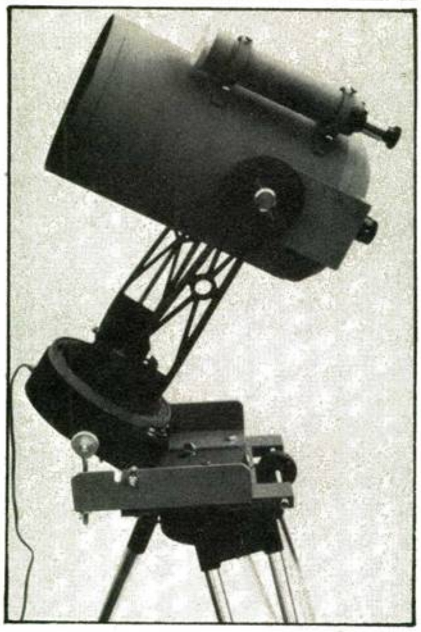
12½", 14¼" $1975 up
CONNOISSEUR SERIES

They're all built better by **The Optical Craftsmen.** We've been supplying fine instruments to the world of astronomy since 1958.

For complete technical data, plus a helpful Messier Observer's Guide, send 50¢ and ask for catalog H.

Additional information about 16", 20", 24" instruments on separate request.

THE OPTICAL CRAFTSMEN, INC.
2190 Shasta Way
Simi Valley, Ca. 93065
(805) 526-7209



DYNAMAX 8® OWNERS

CUSTOM-ENGINEERED ACCESORIES FOR YOUR SCOPE TO ENHANCE ITS OPERATION

- Portable rugged lightweight tripod with fingertip latitude adjustment. Includes the famous POLARIS POINTER™ system. No need to level the tripod or know your latitude to find the celestial pole.
- NO-DU™ CAPS. Removable molded black flock-lined antidewing caps. Heated or unheated models available.
- 50-mm. 7-power right-angle finder. Large prism elbow diagonal. Six-degree field. Mounts in present finder mounting rings 1-1/4". Focusable eyepiece.
- Slow-motion manual declination control. Five times finer adjustment than original equipment.
- VELVET TOUCH™ helical eyepiece focuser. Overcomes mirror focusing image shift.
- TELE-COMPRESSOR. Reduce your photographic exposure time to 25%.
- Coaxial mount for 35-mm. cameras. Mounts with helical stainless-steel ring clamp to rear casting.
- SOLAR-SKREEN™ and CELL ASSEMBLY. Famous patented (USA #3,897,140) sun filter. SAFE because it keeps all the heat out of the scope.

Send for FREE Dynamax 8 catalog today.

Money-back guarantee on all products.

master charge

ROGER W. TUTHILL, INC.
Box 1086A, Mountainside, N.J. 07092
Telephone: 201-232-1786

FOR SALE — Celestron 8 with special coating, tripod, wedge, 8 oculars, 6 glass filters, counterweights, camera attachments, 2" star diagonal. Excellent condition; 2 years old, seldom used. Price: $1,000 firm plus shipping. Contact Bernie Arghiere, 17 Ridge Rd., Fairfax, CA 94930. Phone (415) 457-0763.

FOR SALE — Tasco (model 10-TE) 3" refractor, equatorial mount, tripod, slow motion controls, setting circles, 5 eyepieces, Barlow, camera adapter for Nikon, all accessories, wooden case. 2 years old. Price: $225.00 firm. Contact Frank Augustine, Rt. 2, Box 319-A, Luray, VA 22835. Phone (703) 778-2449.

FOR SALE — New SX-70 kit for SX-70 polaroid and telescope. Will fit Celestron or any other telescope. Made by Robert Little. New, $130.00. Price: $75.00. Contact Bruce Bartholomew, 421 Lake St., Rhinelander, WI 54501. Phone (715) 369-3756.

FOR SALE — 50mm/D,700mm f.l. refractor, altazimuth mount, field tripod, eyepiece/accessory shelf, 4 oculars, sunglass, colored filters, star diagonal, etc. Perfect condition; coated lenses, airspaced objective. Price: $125.00 firm. Write Dr. Julius L. Benton Jr., Thornwell Museum, P.O. Box 60, Clinton, SC 29325.

FOR SALE — Unusual Sears 90mm (3.54") refractor, equatorial mount, flexline slow motions, electric drive, setting circles, 5 oculars, eyepiece turret, Barlow, erector, diagonal, 2 finders. Price: $275.00 plus shipping. Contact John J. Brooks, P.O. Box 645, Mt. Shasta, CA 96067. Phone (916) 926-3204.

FOR SALE — 9-1/2" O.D. optical window plane parallel, 1/8 wave; $30.00. Goto 10mm, 1-1/4" O.D. Huyghens eyepiece; works at f/8; $10.00. 25mm O.D. red Mars filters; $1.50 each. Write Rodger W. Gordon, 637 Jacobsburg Rd., Nazareth, PA 18064.

FOR SALE — Webb's "Celestial Objects for Common Telescopes", frequently referred to in ASTRONOMY's Star Dome; $5.50 for both volumes, ppd. "Skyshooting — Photography for Amateur Astronomers" by Mayall and Mayall; $2.50 ppd. Mint condition. Write Walter Gottlieb, 2 Cypress Rd., Eastchester, NY 10709.

FOR SALE — ASTRONOMY back issues: May 1974 through April 1976. Price: $12.00 plus transportation (just over 10 lbs. unpacked). Write Mabel Sterns, 3025 Ontario Rd. N.W., Washington, D.C. 20009.

FOR SALE — 8" f/8 Newtonian finder, Jaegers optics, extraheavy duty equatorial mount. Custom built to take Jaegers or Edmund drive. Telescope, $130.00; mount and pedestal, $100.00; both for $210.00 plus shipping. Contact Donald L. Davey, 12220 Phoenix Ave. N.E., Albuquerque, NM 87112. Phone (505) 293-7340.

FOR SALE — Hardcover books: "Photography in Astronomy" by Kodak, $4.00; "Sky shooting" by Mayall, $4.00; "The Planet Mercury" by Sandner, $4.00; "Physics of the Planet Mars" by de Vaucouleurs, $8.00. Postpaid. Write Dave Howard, 324 S. Weitzel, Apt. Q, Oceanside, CA 92054.

FOR SALE — Unitron 4" altazimuth refractor, Unihex; many accessories; housed in wooden cabinet. New, used only once; excellent optical, mechanical performance. Price: $825.00 firm; includes shipping, insurance. Contact Dr. Julius L. Benton Jr., P.O. Box 60 Clinton, SC 29325. Phone (803) 833-1232, ext. 65, days.

FOR SALE — 6" f/4 RFT, Coulter optics, aluminum with rack and pinion, wide-angle eyepiece, equatorial on Edmund pedestal, cast legs; will accept Edmund or Jaegers drive. Price: $120.00 plus shipping. Contact Donald L. Davey, 12220 Phoenix Ave. N.E., Albuquerque, NM 87112. Phone (505) 293-7340.

FOR SALE — 10" f/8 Cave Astrola mirror with matching diagonal; $105.00 or best offer. Also 7' Parks fiberglass tube (damaged). Contact Dave Eschhofen, SUPO Box 9740, Tucson, AZ 85720. Phone (602) 624-9081.

FOR SALE — 6" Edmund reflector with equatorial mount, pedestal base, clock drive, 3 eyepieces. Will deliver free in southern California. Price: $100.00 (plus shipping if necessary). Write Tom Fegette, 307 W. Allen, Brawley, CA 92227.

FOR SALE — 10" f/7 Criterion custom deluxe Newtonian, 8 x 50 finder, 60 x 700 guidescope, AC-DC variable drive, rotating rings, camera mount, 7" circles, massive equatorial mount, many extras. Price: $695.00. Contact Emery Hildebrand, 6207 S. Pershing, Downers Grove, IL 60515. Phone (312) 963-4358.

FOR SALE — Best Cave portable equatorial mount for 12-1/2" or smaller scope; 1-1/2" shafts; massive clock drive; 8" circles; electric slow motion in R.A., Dec.; AC-DC frequency drive. New, $750.00. Price: $550.00. Contact Paul C. Hobbs, 2611 Wall St., Signal Hill, CA 90806. Phone (213) 439-4217.

FOR SALE — Superb 20 x 60 binoculars, case. Lightweight; can be hand held or use tripod adapter. Like new. Sacrifice at $75.00. Write Lucky Comunale, 383 Birch Hollow Dr., Shirley, NY 11967.

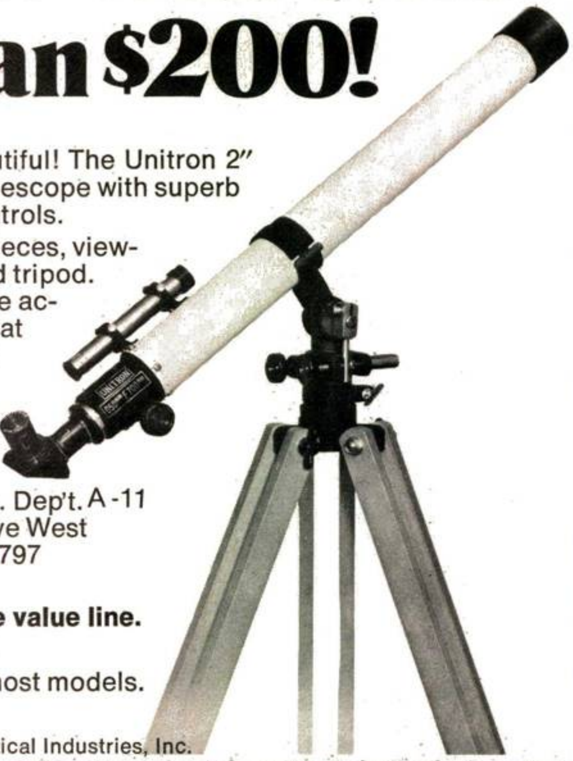
Advertise it free in Astro-Mart.

FOR SALE — 12-1/2" f/5.6 Coulter mirror, 1/25 wave. Excellent. Price: $125.00. Contact E. Wajswol, 81 Sunnyside Way, New Rochelle, NY 10804. Phone (914) 235-1956.

FOR SALE — 10" Cave reflector, f/5.6, 1/25 optics; portable mount; 2", 1-1/4" focusers; clock drive; aluminum circles, 4 eyepieces, special camera mount; special mount for large guidescope. Price: $650.00. Contact E. Wajswol, 81 Sunnyside Way, New Rochelle, NY 10804. Phone (914) 235-1956.

FOR SALE — Celestron 5, 4 eyepieces, equatorial wedge, porro prism, tripod adapter. Price: $500.00 (preferably local). Write Thomas B. Waters, 3703 Bonview Ave., Baltimore, MD 21213.

FOR SALE — Bell & Howell f/8, 36" f.l. telephoto lens. Price: $40.00; no shipping. Contact J. Wingfield, 68 Offutt Rd., Bedford, MA 01730. Phone (617) 274-7337.



Now you can own a genuine Unitron for less than $200!

It's brand new! It's beautiful! The Unitron 2" Altazimuth Refractor Telescope with superb optics and precision controls.

Complete with two eyepieces, viewfinder, star diagonal, and tripod. Thanks to many available accessories, it's a scope that can grow along with you in the fascinating world of astronomy.

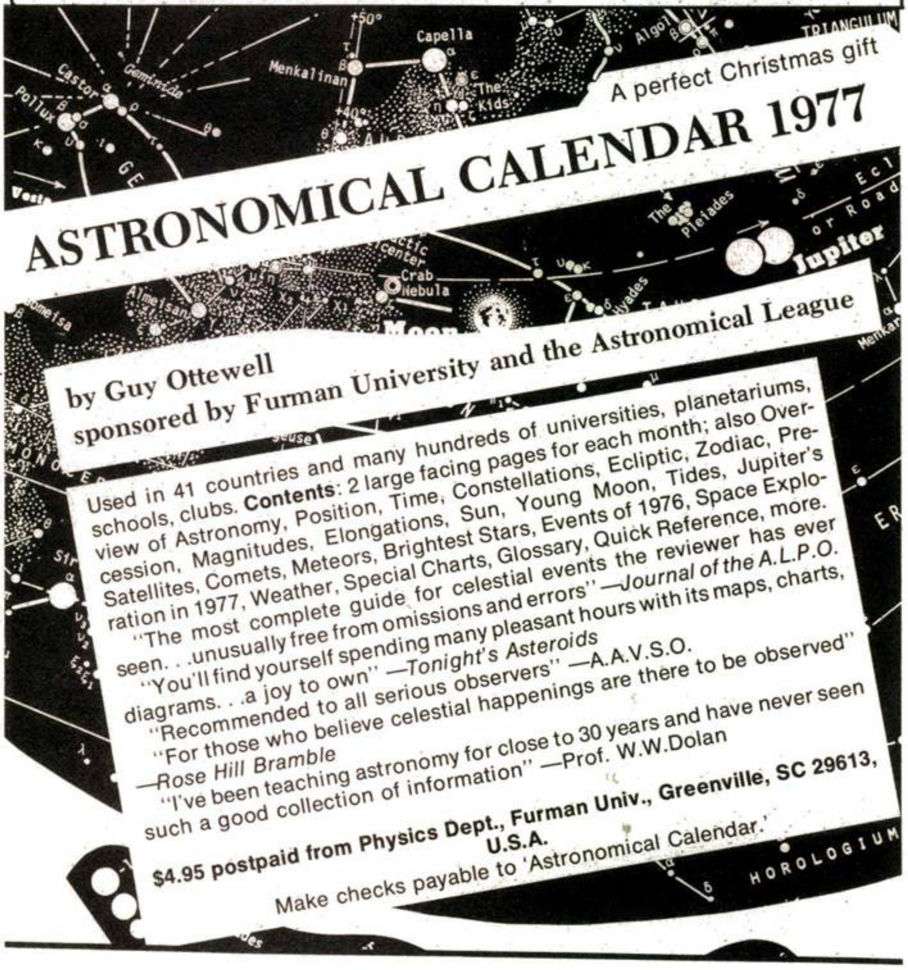
Ask us for a catalog and dealer list.

Unitron Instruments, Inc. Dep't. A-11
101 Crossways Park Drive West
Woodbury, New York 11797

UNITRON **The value line.**

Immediate delivery on most models.

Unitron Instruments, Inc.
Sub. of Ehrenreich Photo-Optical Industries, Inc.



A perfect Christmas gift

ASTRONOMICAL CALENDAR 1977

by Guy Ottewell
sponsored by Furman University and the Astronomical League

Used in 41 countries and many hundreds of universities, planetariums, schools, clubs. **Contents**: 2 large facing pages for each month; also Overview of Astronomy, Position, Time, Constellations, Ecliptic, Zodiac, Precession, Magnitudes, Elongations, Sun, Young Moon, Tides, Jupiter's Satellites, Comets, Meteors, Brightest Stars, Special Charts, Glossary, Quick Reference, more. Events of 1976, Space Exploration in 1977, Weather,

"The most complete guide for celestial events the reviewer has ever seen. . .unusually free from omissions and errors" —*Journal of the A.L.P.O.*

"You'll find yourself spending many pleasant hours with its maps, charts, diagrams. . .a joy to own" —*Tonight's Asteroids*

"Recommended to all serious observers" —A.A.V.S.O.

"For those who believe celestial happenings are there to be observed" —*Rose Hill Bramble*

"I've been teaching astronomy for close to 30 years and have never seen such a good collection of information" —Prof. W.W.Dolan

$4.95 postpaid from Physics Dept., Furman Univ., Greenville, SC 29613, U.S.A.

Make checks payable to 'Astronomical Calendar.'

Equatorial Mounts

10" I.D. Rings
Drives · Circles

☆

Slow motion for both axes

☆

Complete mounts - 6" and 8"
Individual Castings and parts

Mounts start at $117.00

Write for free catalog

Pacific Instruments
P.O. Box 1876A, Pacoima CA 91331 (213) 896-3016

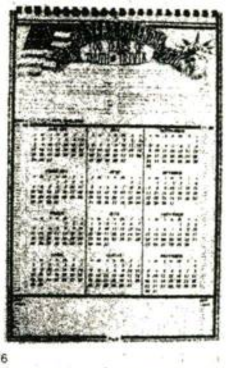
A unique calendar for all the days of your life

Covers the entire period from Bicentennial 1976 through Tricentennial 2076.

13" x 20", spiral bound
Send

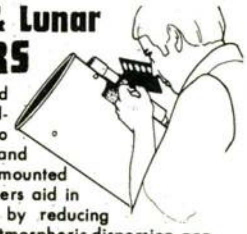
$3 95 plus $1.00 for postage and handling to

101 Year Calendar
506 Bellevue
Daytona Beach, Fla. 32014



© Jack Young, Inc. 1976

Planetary & Lunar FILTERS



Five widely used precision color filters so essential to serious planetary and lunar observers mounted in sturdy card. Filters aid in observing details by reducing glare, minimizing atmospheric dispersion, penetration of planets atmosphere, increasing color contrast, and reducing irradiation. Wratten numbers; 21-orange, 25-red, 38A-light blue, 47-violet, 58-green. Includes instructions. A must at all telescopes

7.50 Ppd.

Send Check or Money Order to:
FT. WAYNE ASTRONOMICAL SOCIETY INC.
P.O. Box 6004 Ft. Wayne, Indiana 46806

Observatory Domes
to highest professional standards
Aluminum, Fiberglass, Steel
+
Planetarium Projection Domes
+
Exclusive Sales Agents
in the United States and Canada
for the incomparable Zeiss Planetarium.

ZEISS
THE GREAT NAME IN OPTICS

Observa·DOME

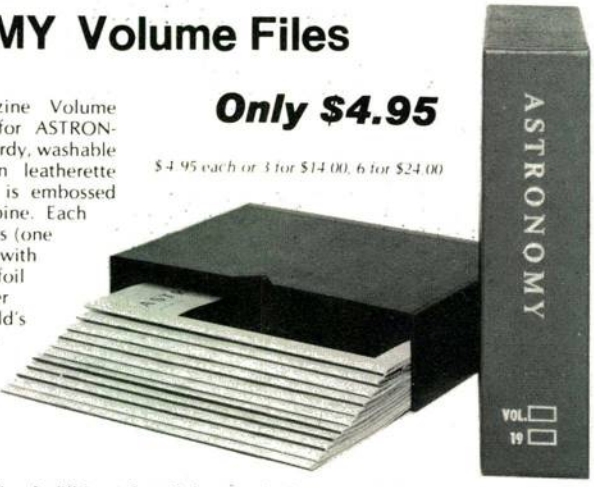
371 Commerce Park Dr. / P. O. Box 885 / Jackson, MS 39205
Phone (601)982-3333

ASTRONOMY Volume Files

Only $4.95

$4.95 each or 3 for $14.00, 6 for $24.00

Custom designed magazine Volume Files are now available for ASTRONOMY subscribers. These sturdy, washable cases have a rich brown leatherette finish, and ASTRONOMY is embossed in elegant gold on the spine. Each case holds 12 80-page issues (one complete year), and comes with a slip of gold signature foil to fill in volume number and year. Keep the World's Most Beautiful Astronomy Magazine beautiful year after year with this impressive addition to your library.



To order, simply fill in and mail the attached coupon today!

Use this address ONLY for Volume File orders and correspondence regarding them.

ASTRONOMY Volume Files
P.O. Box 5120
Philadelphia, PA 19141

Enclosed is $______ in payment for the following ASTRONOMY Volume Files:

______ 1 for $4.95 ______ 3 for $14.00 ______ 6 for $24.00

Name ____________________

Address ____________________

City __________ State ______ Zip ______

U.S.A. orders only. Allow 3 weeks for delivery.
Full money back guarantee

FOR SALE — Collection of over 150 hardcover and paperback science and science fiction books. Excellent condition. Send 25¢ for complete list to Robert C. Cardwell, SR 97, Lot 135, Bellville, OH 44813.

FOR SALE OR TRADE — Zeiss microscope, 25x-1350x. Price: best offer over $300.00. Write P. Signorelli, P.O. Box 6068, Colorado Springs, CO 80934.

TRADE — Beaulieu 5008-S movie camera (most expensive and best Super-8 with sound) with accessories and Bolex 18-5L projector. Both seldom used. Trade for Cave 12" compact or similar scope. Write Robert Sullivan, 4115 Brooklyn, #204, N.E. Seattle, WA 98105.

WANTED — Members for "National Deep Sky Observers Society" (must have telescope). Special programs, no fees. For information, write Alan Goldstein, NDSOS National Coordinator, 3430 Bryan Way, Louisville, KY 40220. Or Roy Kampfer, NDSOS Eastern Coordinator, Forrest Central Dr., Titusville, NJ 08560.

WANTED Correspondence on theoretical possibility of faster-than-light travel, theory of relativity and gravitation. Write Rudolf F. Haig, 1650 Octavia St. - #307, San Francisco, CA 94109.

Future Positions with ASTRONOMY

The following positions do not currently exist but represent jobs that will materialize at ASTRONOMY as we expand during the next 12 to 36 months. If you will be graduating from college during this period or if you'd just like us to keep you in mind as positions open, we invite you to send a letter of application and resume for our files.

★Copy Editors / Staff Writers★

Requires knowledge of amateur and theoretical astronomy in varying degrees from sophisticated amateur level to college degree in descriptive astronomy and experience as planetarium program writer/lecturer. College degree a must with major in magazine journalism. Creative ability, driving motivation and enthusiasm are desirable qualities for these positions. Salary open and commensurate with education, ability and previous, related employment experience.

★Editorial Researchers / Indexers★

Requires strong familiarity with amateur and theoretical astronomy. College degree a must with major in English and coursework in writing, journalism and library science. Library science degree is desirable. Salary open and commensurate with education/employment experience and ability.

★Editorial Scientists★

Ph.D astronomer(s) with both the ability to write for a nonscientist audience and broad knowledge of professional astronomical research being conducted in fields other than your speciality. Salary open and commensurate with scope of knowledge and ability to write.

★Proofreaders / Style Editors★

Requires strong familiarity with amateur and theoretical astronomy. College degree in English or journalism (preferred), although some college with coursework in English and journalism is acceptable.

WANTED — Used Celestron, 750mm f/6 lens. Also older 3" Questar. Write Don Scott, 389 Princeton, Ventura CA 93003.

WANTED — Back issues of ASTRONOMY: January, February, April, May, August 1974. Send prices for any or all. Will pay any reasonable price. Write Steven J. Johnston, P.O. Box 17, Lakeview OH 43331.

WANTED — January 1976 issue of ASTRONOMY; must be in good condition. Will pay any reasonable price. Write Richard Redgate, 78 Mara Rd., Lake Hiawatha, NJ 07034.

WANTED — Correspondence with persons interested in exchanging ideas, data on time machine; interstellar travel; transport vehicles that derive propulsion power from electric, magnetic fields; how to extract electricity directly from Earth's electric field. Write Jairto G. Santos, Caixa Postal 2055, 01000 Sao Paulo, S.P., BRAZIL.

WANTED — Pair of very large aperture (120mm or so) binoculars. Send details to Hugh A. Simpson, P.O. Box 611, Amite, LA 70422.

WANTED — Comic books; will pay up to 10 times the cover price for certain ones. Send list, stating condition, to Patrick L. Vaughan, P.O. Box 203, Springdale, AR 72764.

INFORMATION WANTED — On mirror grinding (all types except Newtonian). Also plans for constructing mirror grinder for mirrors up to 20" diameter. Write Alan Goldstein, 3430 Bryan Way, Louisville, KY 40220.

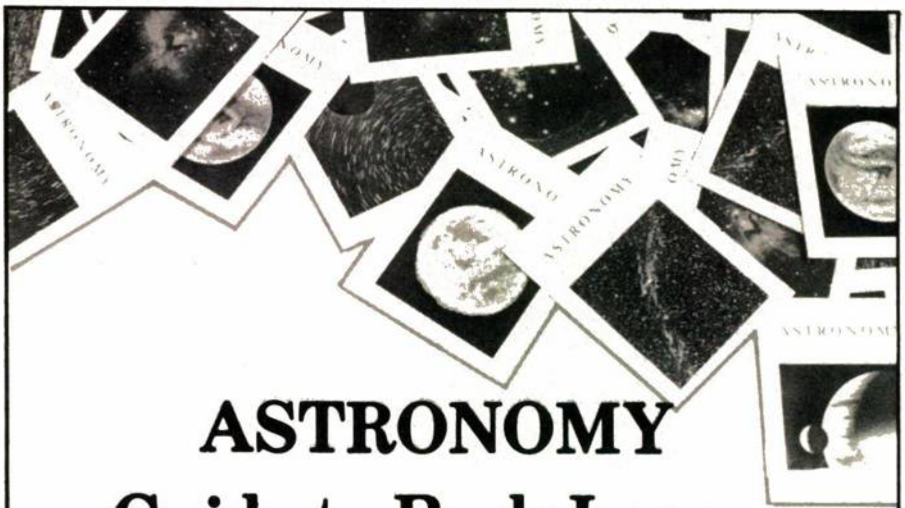
INFORMATION WANTED — On astronomy clubs, persons interested in astronomy in Gary area. Write Russell Yeagley, 816 N. County Line Rd., Apt. F, Gary, IN 46403.

ANNOUNCEMENT — Joint expedition between 3 local astronomical societies being organized to observe spectacular lunar occultation on Nov. 25 near Texas City. Persons with 3" or larger scopes should contact Paul Maley (713) 488-6871; Bob Bailey (713) 523-9804; Lamont Brock (713) 495-1997.

ANNOUNCEMENT — New astronomy club of Livonia meets at 8 p.m. on the second Wednesday of every month (except December) at Holmes Junior High School, 16200 Newburgh Rd. Everyone welcome. For information, contact Mike Best, Box 121, Livonia, MI 48152. Phone (313) 478-9940.

ANNOUNCEMENT — Marks Astronomical Society of the Palm Beaches is hosting Stellathon '76 (Nov. 12-14, 1976) at Youth Conservation Camp, north central Palm Beach County, Florida. Speakers, telescope competitions, observational sessions, etc. For details, write Ric Lasher, 814 Date Palm Dr., Lake Park, FL 33403.

FREE — Proof, calculations: velocity of light reflected by Mercury can be increased by twice planet's orbital velocity; Unified Field theory based on Newtonian force equals mass X acceleration, bodies radiate mass to produce field. Write William T. Thomas Jr., 408 Vermont Ave., Daytona Beach, FL 32018.



ASTRONOMY

Guide to Back Issues

Reader interest in back issues of ASTRONOMY magazine is higher than ever. As a result, our stock of back issues is swiftly dwindling. Below is a guide to ASTRONOMY back issues that are still available. For your convenience it is updated monthly; issues not listed are depleted. **The July 1976 History of American Astronomy issue is specially priced at $3.50 per copy plus postage.**

When ordering, please clearly state quantity, volume, number, month and year for each issue (first issue was August 1973), and include payment with your request. If issues ordered are no longer available, unless you instruct us to forward a refund or substitute issues, we will automatically extend your subscription appropriately.

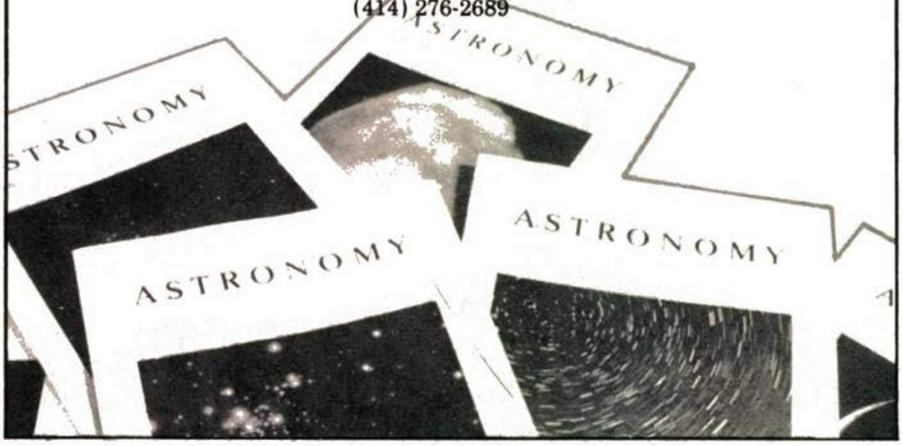
***$1.50** per copy*
U.S. — Add $1.00 per order
Canada/Mexico — Add $2.00 per order
All Other Foreign — Add $2.50 per order

Vol. 1, No. 1 - August 1973	**Available**	**Vol. 4, No. 2 - February 1976**	**Available**
Vol. 2, No. 3 - March 1974	**Short Supply**	**Vol. 4, No. 3 - March 1976**	**Available**
Vol. 2, No. 6 - June 1974	**Short Supply**	**Vol. 4, No. 4 - April 1976**	**Available**
Vol. 2, No. 7 - July 1974	**Short Supply**	**Vol. 4, No. 5 - May 1976**	**Available**
Vol. 2, No. 9 - September 1974	**Short Supply**	**Vol. 4, No. 6 - June 1976**	**Available**
Vol. 2, No. 10 - October 1974	**Short Supply**	**Vol. 4, No. 8 - August 1976**	**Available**
Vol. 2, No. 11 - November 1974	**Short Supply**	**Vol. 4, No. 9 - September 1976**	**Available**
Vol. 3, No. 1 - January 1975	**Short Supply**	**Vol. 4, No. 10 - October 1976**	**Available**
Vol. 3, No. 5 - May 1975	**Available**	**Vol. 4, No. 11 - November 1976**	**Available**
Vol. 3, No. 6 - June 1975	**Available**	**Vol. 4, No. 12 - December 1976**	***NYP**
Vol. 3, No. 7 - July 1975	**Available**	**Vol. 5, No. 1 - January 1977**	***NYP**
Vol. 3, No. 8 - August 1975	**Available**	**Vol. 5, No. 2 - February 1977**	***NYP**
Vol. 3, No. 9 - September 1975	**Available**	**Vol. 5, No. 3 - March 1977**	***NYP**
Vol. 3, No. 10 - October 1975	**Available**	**Vol. 5, No. 4 - April 1977**	***NYP**
Vol. 3, No. 11 - November 1975	**Available**	**Vol. 5, No. 5 - May 1977**	***NYP**
Vol. 3, No. 12 - December 1975	**Available**		

*Not Yet Published

Please allow at least four (4) weeks for delivery.

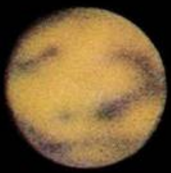
Rosemary L. Pickart
ASTRONOMY Magazine
411 E. Mason, 6th Floor
Milwaukee, WI 53202
(414) 276-2689



Planet Finder

Ⓒ Ceres

Nov.	1	15
R.A.	11h21m	11h42m
Dec.	+ 13° 10'	+ 11° 38'
Mag.	+ 8.5	+ 8.3



Ⓐ Mercury

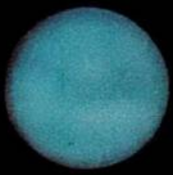
Nov.	1
R.A.	14h16m
Dec.	-12° 56'
Mag.	-0.9

Ⓑ Mercury

Nov.	15
R.A.	15h45m
Dec.	-20° 41'
Mag.	-0.7

Ⓜ Mars

Nov.	1	15
R.A.	14h56m	15h36m
Dec.	-16° 49'	-19° 31'
Mag.	+ 1.7	+ 1.6



Ⓝ Neptune

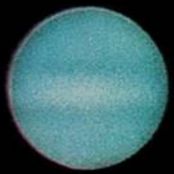
Nov.	15
R.A.	16h46m
Dec.	-20° 54'
Mag.	+ 7.7

SUN

The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

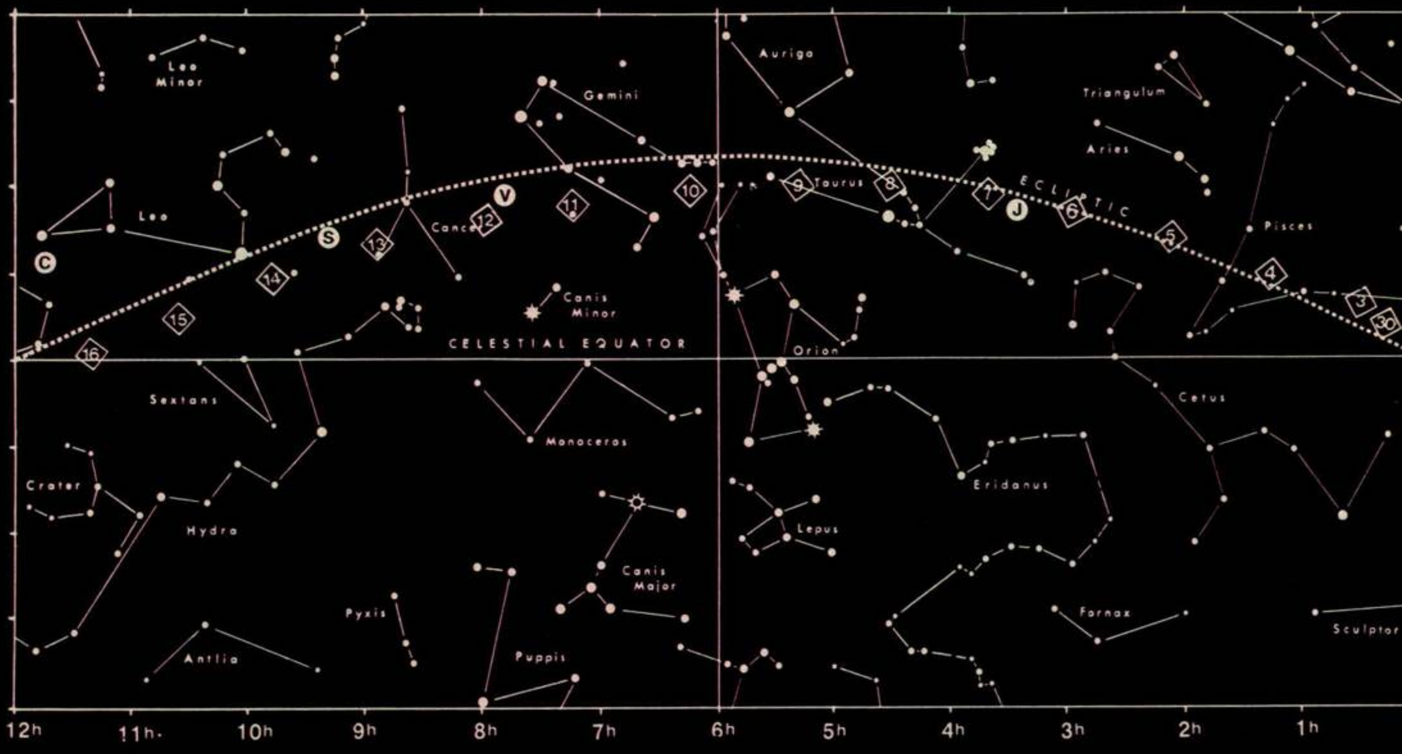
Ⓢ Saturn

Nov.	1	15
R.A.	9h15m	9h17m
Dec.	+ 16° 38'	+ 16° 31'
Mag.	+ 0.6	+ 0.6



Ⓤ Uranus

Nov.	15
R.A.	14h25m
Dec.	-13° 55'
Mag.	+ 5.7


Leo Minor
Gemini
Auriga
Triangulum
Aries
Leo
Cancer
Taurus
ECLIPTIC
Pisces
Canis Minor
CELESTIAL EQUATOR
Orion
Sextans
Cetus
Monoceros
Eridanus
Crater
Hydra
Lepus
Canis Major
Pyxis
Fornax
Sculptor
Antlia
Puppis
C
S
V
J
16
15
14
13
12
11
10
9
8
7
6
5
4
3
30
12h
11h
10h
9h
8h
7h
6h
5h
4h
3h
2h
1h

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec . = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag . = magnitude, a

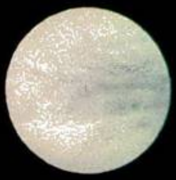
November 1976

Ⓥ Vesta

Nov.	1	15
R.A.	7h44m	7h50m
Dec.	+ 19° 35'	+ 19° 44'
Mag.	+ 7.9	+ 7.7

Ⓙ Jupiter

Nov.	1	15
R.A.	3h45m	3h37m
Dec.	+ 18° 39'	+ 18° 15'
Mag.	-2.4	-2.4



Ⓨ Venus

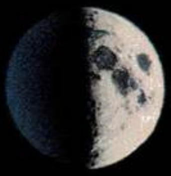
Nov.	1
R.A.	16h53m
Dec.	-24° 05'
Mag.	-3.5

Ⓩ Venus

Nov.	15
R.A.	18h08m
Dec.	-25° 26'
Mag.	-3.5

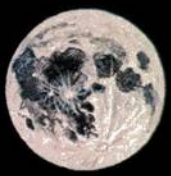
Ⓟ Pluto

Nov.	15
R.A.	13h13m
Dec.	+ 10° 13'
Mag.	+ 14



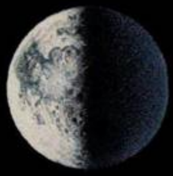
First Quarter

November 28



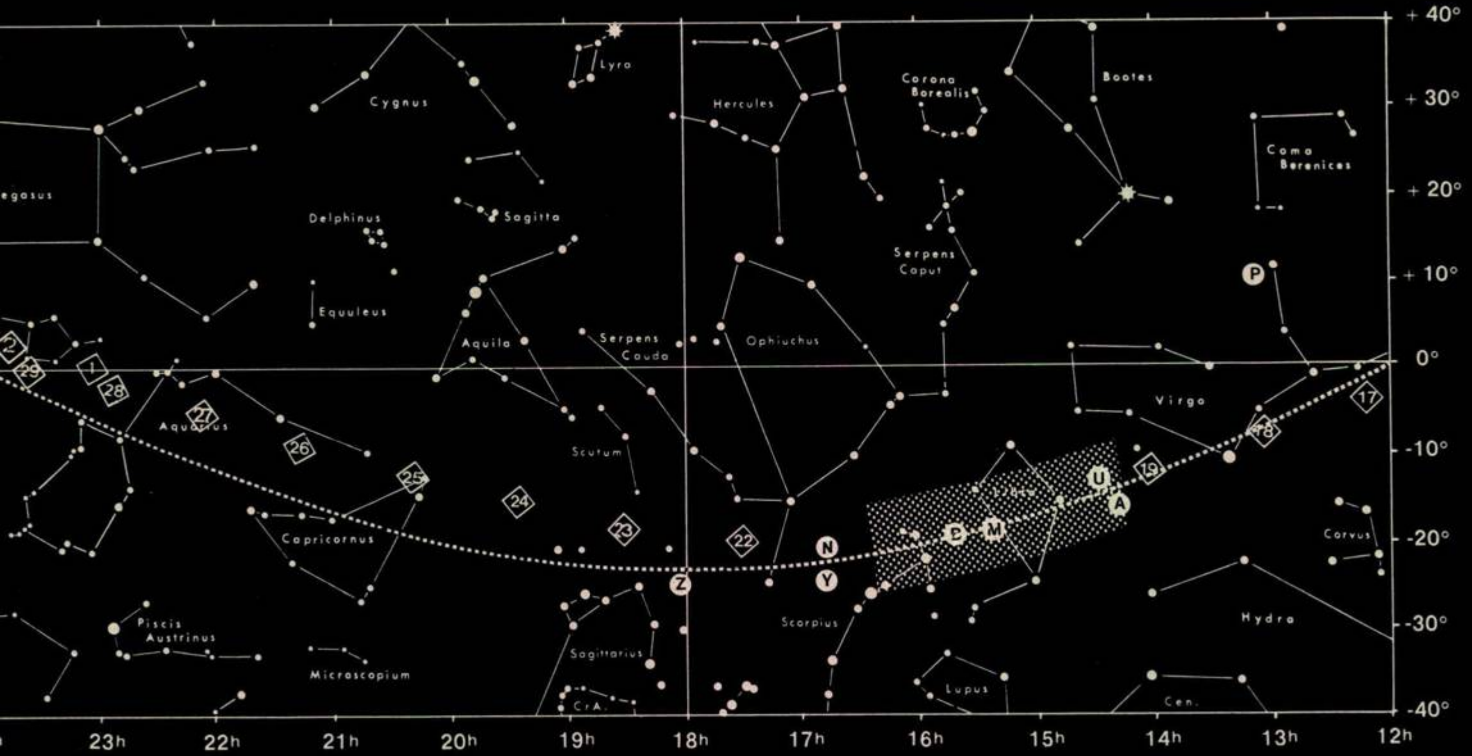
Full Moon

November 6

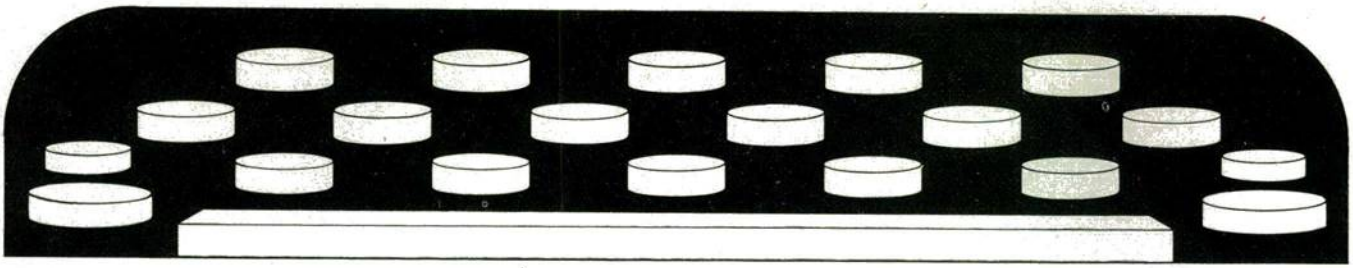


Last Quarter

November 14


+ 40°
+ 30°
+ 20°
+ 10°
0°
-10°
-20°
-30°
-40°
23h
22h
21h
20h
19h
18h
17h
16h
15h
14h
13h
12h
Lyra
Cygnus
egasus
Delphinus
Sagitta
Equuleus
Aquila
Aquarius
Capricornus
Piscis Austrinus
Microscopium
Scutum
Serpens Cauda
Sagittarius
CrA.
Hercules
Ophiuchus
Scorpius
Corona Borealis
Serpens Caput
Libra
Lupus
Bootes
Virgo
Hydra
Cen.
Coma Berenices
Corvus
P
N
Y
Z
U
A
M
1
17
18
19
22
23
24
25
26
27
28
29

measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.



IN FOCUS

Sir / As a charter subscriber to ASTRONOMY, I have derived a fair amount of enjoyment and education from the magazine. But I do have a few suggestions for improvement.

Pictures are great — but not as background to text. The object of text is to be read. Some of your articles (for example, book reviews) are printed over pictures, or just gray or colored backgrounds, which make the text nearly illegible.

Your artwork, in general, is awful. Good artwork can be very useful when it clarifies and informs (for example, your diagrams of the ecliptic angle's effect on moonrise). However, artists' flights of fancy on black holes, Venusian landscapes and the like really contribute nothing. The space they take up could be better used for more photography, diagrams of various kinds, text or almost anything else. Eyepiece impressions are fine; meaningless blobs and swirls of color are really nothing.

BARRY GORDON
New York, N.Y.

Mr. Gordon / A picture that serves as background to text is known as a "phantom shot". In such cases, the picture is not reproduced "full strength", but is toned down to make text readable and provide visual attractiveness at the same time.

Your objections to artwork of the kind provided by ASTRONOMY seem to indicate your preference for theoretical, rather than artistic, description. The Venusian landscapes by Adolf Schaller and James Hervat in the August 1976 issue are their attempt to visualize scenes and places in ways that an equation, or the kind of dry verbal descriptions found in most scientific papers, cannot. The visual beauty and drama of astronomy is sometimes best conveyed in paintings — especially those of the quality that ASTRONOMY tries to provide.

In addition, ASTRONOMY is now reproducing more and better photographs than ever before, striking a balance between artwork and photos, and making ASTRONOMY a more beautiful magazine than ever.

Sir / I have been an appreciative subscriber to ASTRONOMY since its inception and feel that the general quality of the publication is first rate. Your recent format changes in Star Dome, however, merit some comment.

In my opinion, the strong chart colors used for the constellation close-up of your September 1976 issue detract from the visibility of the fainter stars portrayed. Assuming that the magnitude limit has not, in fact, been lowered, the ease of seeing faint objects on this chart has been considerably reduced.

There are also editorial errors in this section, as it appears that two of the three figures (Altair and 15 Aquilae) do not correspond to the descriptions given in the text.

I have confidence that you will continue to maintain your usual high standards and improve on this section in particular.

ROBERT E. MILLS
Mastic Beach, N.Y.

Mr. Mills / The heads for the eyepiece views of Altair and 15 Aquilae were accidentally switched. Other readers have pointed out that two stars on the September map are marked δ; the northernmost of these two should be γ. We apologize for these errors.

The "strong chart colors" you object to on the September map have since been toned down, making the map more readable. What do other readers think of the colors on the Star Dome map — as well as the other recent changes in the Star Dome format?

Sir / In your July 1976 issue, you published a number of reproductions of sketches by Trouvelot. Can you refer me to any books or publications about this man or any works that reproduce his sketches and paintings as a whole?

WILLIAM McCAWLEY
Long Beach, Calif.

Mr. McCawley / The drawings by E.L. Trouvelot, some of which were reproduced in the July issue, are very rare. Produced by the artist in the 1870s and 1880s, the original drawings were printed as a folio set of 28" x 32" individual sheet prints. Only a few sets were produced, and no color reproductions are available. An accompanying volume (also rare) to the folio contains black and white reproductions of the drawings with a short description of each; it may be possible to find a copy at the libraries of the more prominent universities.

Sir / By chance, I read a few issues of ASTRONOMY that belong to a friend. I was immediately pleased with the presentation of your subject material, and like the less technical, more conversational approach you. issues seem to take.

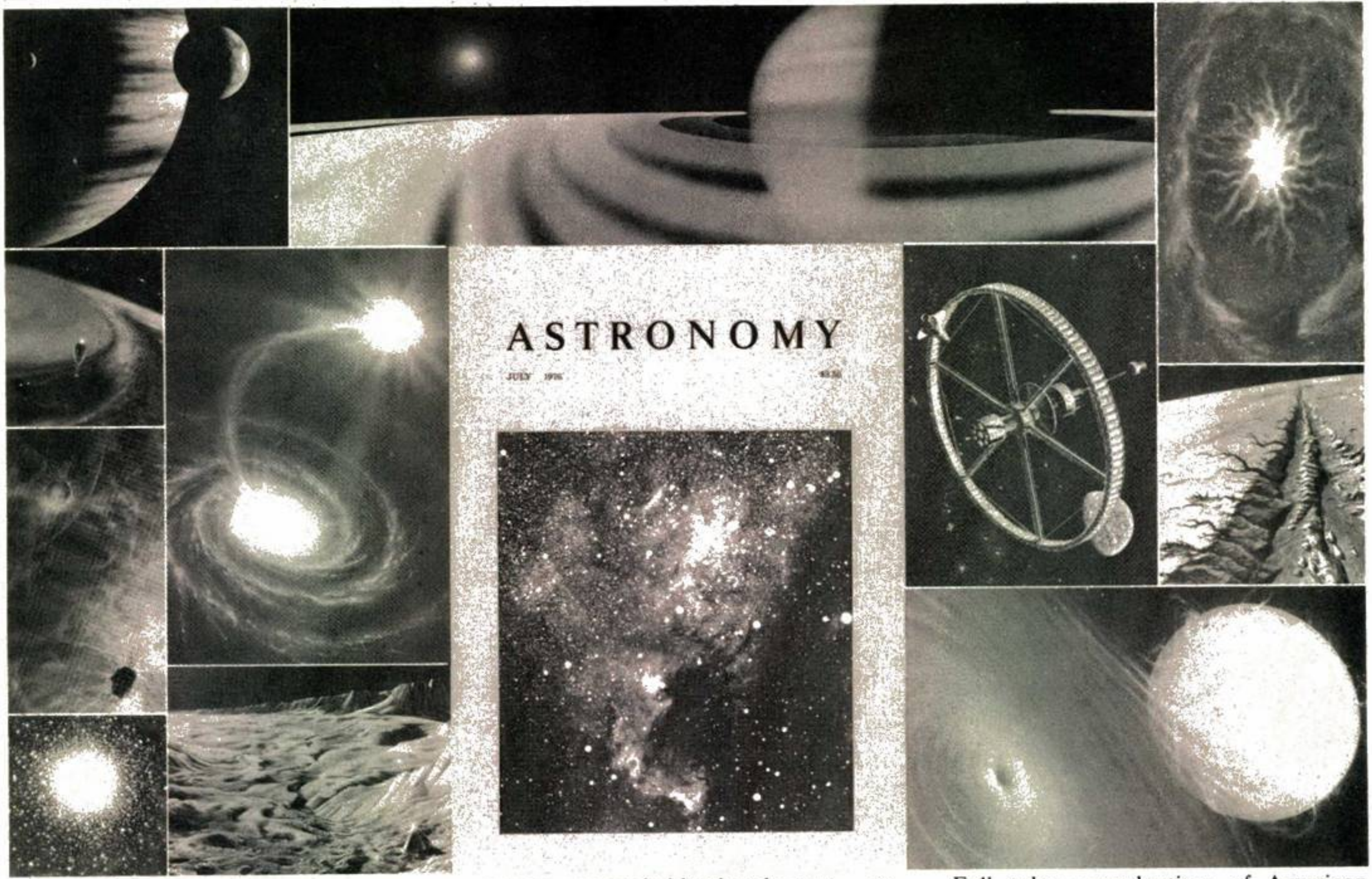
I do not have radio telemetry, oı a Palomar Observatory, nor photoelectric equipment in series with sophisticated computers. It is obvious that the science of astronomy is also a science of mathematics. At the same time, that science belongs to a select society — and it's grand to have that society.

There are many of us who derive simple pleasure from merely looking at a starry sky and enjoying what there is to see. Not only is there the main attraction of a star-studded cast, but regular guest appearances by comets, eclipses, meteors and moon phases. It is one of the few subjects that allows running amuck in either the scientific or esthetic sense.

I admit that I am a photographer and have a large telescope, and that I do need numbers to guide me to the coordinates I wish to photograph. The numbers get me where I want to go to see the show. Beyond that, the numbers belong to the scientists. As Henry M. Neely wrote in his book on star identification: ". . . ancient love of simple star-gazing (hopefully will be rescued) from the avalanche of mathematics and physics under which modern astronomy threatens to bury it." ASTRONOMY may reside in that area of rescue. I hope so.

WILLIAM B. DRURY
Shepherdsville, Ky.

Man's Dream of Worlds Unseen



ASTRONOMY

* * * * * * * * * * * * * * * * * * * *

Bill Hartmann and Adolf Schaller are a team. A very unusual team indeed — scientist Hartmann and artist Schaller working together to open the complex vistas of the universe.

Three years ago **ASTRONOMY** magazine established a hallmark of beauty and readership intimacy seldom found today. And each month since then it has followed through with full color paintings and photographs, clear and pictorial writing, inviting layout and design, uncompromised printing quality... care and committment to you the subscriber. **ASTRONOMY** makes the universe appealing. It transforms alienating theory to inviting, entertaining discovery.

Join 52,000 **ASTRONOMY** subscribers to discover the excitement of space and astronomy with Fred Whipple (comets), Joseph Veverka (Mars), Gerrit Verschuur (radio astronomy), David Morrison and Michael Ovenden (asteroids), George Abell (galaxies), William Hartmann (Saturn), Thomas Easton (life on Mars) Jay Pasachoff (sun), Frank Drake (neutron stars)... scientists of worlds unseen.

ASTRONOMY's monthly departments guide you to astrophotography with cameras you probably already own — to the use of telescopic equipment — to location and observation of planets, constellations, asteroids, comets, galaxies, double stars, star clusters... to all the cosmic beauty awaiting your personal discovery.

Book reviews guide your astronomy reading and Astro-News keeps pace with the latest discoveries, research and findings... brought to you while they're still news.

History of American Astronomy

And now, **ASTRONOMY** proudly presents a very special bicentennial celebration issue entirely devoted to the evolution of astronomy in the United States.

This exciting full color epic takes you from the prehistoric astronomy practiced by indigenous Americans, to the birth of astrophysics and development of astrophotography, through 20th century American astronomy — the discovery of quasars, pulsars, black holes — and the start of our nation's third century, "Toward Man's Dream of Worlds Unseen".

Noted authors — Von Del Chamberlain (Smithsonian Institution), Trudy E. Bell (Scientific American editor), Richard Berendzen (American University, Washington, D.C.), Michael Mendillo (Boston University), and David DeVorkin (Central Connecticut State College) — unfold the history of American astronomy with drama and refreshing writing style.

Full color reproductions of American astronomical art from the 1800s, antique brass telescopes and instruments, portraits of famous American astronomers and color sky photographs from leading observatories across the country, are interspersed with equally historic wood cuts and the first astrophotographs of the sun, moon and Milky Way.

We invite you to join us as a subscriber and receive the July 1976 **"History of American Astronomy"** issue as a portion of your subscription.

Collect **ASTRONOMY**... treasure this and every issue of "The World's Most Beautiful Astronomy Magazine"... no other magazine of space and astronomy has ever been able to make so great a claim — and keep its word.

American Bicentennial Subscription Offer

Subscribe to **ASTRONOMY** magazine for $12.00 and save $5.50 off the regular newsstand price of $16.50 for 11 copies. We'll bill you later. After you pay your bill you will receive as the 12th copy of your subscription the July **"History of American Astronomy"** issue at the paid subscriber price of only $1.00 — you save $2.50 off this copy alone. Your total savings on this 12 issue American Bicentennial Subscription offer is $8.00 (40%) off the single copy newsstand price.

ASTRONOMY

The World's Most Beautiful Astronomy Magazine

Established: August 1973. Published monthly by Astro-Media Corp., 411 E. Mason St., 6th Floor, Milwaukee, WI 53202. Per Year: Canada /Mexico, $15; Other Foreign, $18. Offer expires Dec. 31, 1976.

VIKING 1 AND 2 COLOR SLIDES – "LIFE ON MARS?"

The 5 slide sets listed here, when combined, contain every color photo of the surface of Mars taken by Viking 1 and 2 as well as spectacular panoramas and high resolution closeups in black and white. Additional Viking 2 slide sets will be offered next month. All slides are the new computer processed versions and feature true color adjustments by the JPL Image Processing Laboratory. They provide the most accurate and detailed views of the Red Planet to date. Even the television scanning lines are sharp and distinct. All slides are SUPER 35MM frames (42% more viewing area for a brighter, more detailed projected image than with standard 35mm) in 2"x2" mounts to fit all projectors. Several pages of official JPL descriptions are included with each set.

VIKING 1

SET A - Beautiful approacn photos in color showing the half phase of Mars (Martian "Grand Canyon", giant volcanos, cirrus-like clouds, etc.), Chryse Planitia landing site from orbit (closeup and mosaics of region), spectacular oblique view of Olympus Mons with clouds near summit, water channels, "islands", and more.

15 Slides **$5.50**

SET B - A unique color view of the soil sample scooper next to the trenches it dug with rocky dune fields and the horizon in the background, beautiful sunset from surface (colorful concentric arcs and horizon silhouette), ground fog in river channels and craters, evidence of subsurface ice melting, the other side of Phobos, and more.

15 Slides **$5.50**

SET C - The American flag and colorful emblems on the spacecraft against a background of the bright orange-red surface and pink sky of Mars, orange descent rocket cable and Martian surface, "human face" rock formation, great avalanches, surface panorama showing sand dune ripples and boulder fields at low sun angle, and more.

15 Slides **$5.50**

SET D - Dune fields of reddish granular material, blue-black soil, greenish rocks with red stains, the colorful horizon rock cluster and sky, 300° surface panorama, figure "8" etched in rock, "water-logged" craters, massive sand dunes climbing the walls of Gangis Chasma, and more.

15 Slides **$5.50**

VIKING 2

SET A - Color panorama showing tens of thousands of rocks on the Utopian plains, color view of spacecraft antenna and large porous boulders, color intensity variations of the Martian sky, Utopia Planitia landing site (orbital closeup and mosaics of region), unexplained geometric surface features, 330° surface panorama, oblique closeup of north polar cap, and more.

15 Slides **$5.50**

SLIDES AND MOVIES – SPACE EXPLORATION

These are the slide sets and movies chosen by NASA for sale at the Kennedy Space Center. In addition, they have been sold at the Jet Propulsion Laboratory and at various aerospace plants (a testimonial to their quality). We are the official distributors of these materials and, by special arrangement with the manufacturer, are offering them below the regular retail prices. Order now while supplies last. All slides are 35mm.

Sets of 20 Color Slides . . . . **$4.75 ea.**

A set of 20 slides is available for each of the missions listed below. Each set provides a complete outline coverage of the mission. Order by mission number.

Apollo 8, 9, 10, 11, 12, 13, 14,15, 16, 17

Skylab 2, 3, 4; Apollo/Soyuz; Mariner 9 - Mars

Sets of 80 Color Slides . . . . **$19.75 ea.**

A set of 80 slides is available for each of the missions listed below. These sets provide the most extensive coverage available for a mission. Order by mission number. Complete with several pages of descriptions.

Apollo 12, 14, 15, 16, 17

SPECIAL! Apollo 11 . . 100 Color Slides. $24.75

200 ft. 8mm Color Movies . . . . **$19.75 ea.**

A 200 ft. color movie is available for each of the missions listed below. These movies provide extensive footage for each phase of the mission. Order by mission number and please specify regular or super 8mm.

Apollo 10, 11, 12, 14, 15, 16, 17

Apollo/Soyuz

SPECIAL! Skylab 2, 3, 4 covered in one movie

150 Ft. **$15.75**

Postage: U.S.A. $ .50 Canada $1.50 Elsewhere $3.00 Sales Tax: 6% (Calif. only)

OPTIKEN INTERNATIONAL GMBH, 900 So. San Gabriel Blvd. San Gabriel, California 91776

STAR DOME

NOVEMBER

by
James Mullaney and Henry J. Phillips

Which came first, our constellations or the myths connected with them? At first glance, the answer seems obvious — the star groups had to exist before any legends relating to the figures depicted could be told. On the other hand, why do certain constellations bear the names they do? Was there anything special about a star pattern that made our ancestors attach the name of a particular hero to it?

These questions are particularly appropriate this month, for crossing the meridian in the November sky are Cepheus, Cassiopeia, Pegasus, Andromeda, Perseus and Cetus — six constellations portraying figures that are involved in a single story. Did the star groups involved inspire the well-known myth in which all play parts? Or did the myth come first, with its characters placed in the sky later?

We must remember that the names by which we know these constellations today are not their original titles. The origins of all our constellations are lost in the distant past; the star patterns were probably identified by primitive men who left no written records. We do know, however, that most of our current star groups were known to the inhabitants of Mesopotamia by at least 2000 B.C. When the Greek cultures began their ascendancy, they took over the Mesopotamian figures without changing them, merely applying the names of their own heroes and animals in preference to the ones they inherited.

Thus, we know the characters in the well-known myth of Perseus by their Greek names, although the actual story probably had its origins in Babylonia or Persia. The myth is so famous that another telling of it may be superfluous. Nevertheless, for those who don't know it — and to correct a few errors — we'll relate it here.

We must begin with Perseus, who has the most important role to play. The son of the god Zeus and a mortal woman, Danaë, Perseus was fated to kill his grandfather Acrisius. Fearing the oracle, Acrisius had Danaë and her infant son set adrift on the sea in a wooden chest, which washed ashore in the realm of Polydectes. Perseus grew to manhood under Polydectes' watchful eye, and the king soon grew to hate the hero. At a festival, Perseus made a rash boast that he could kill the Gorgon Medusa, whereupon Polydectes immediately sent him to do so, thinking Perseus would never return alive.

There were three Gorgons, of whom only Medusa was mortal. They were once-beautiful women who had been turned into frightful monsters with live snakes instead of hair, and anyone who saw them was instantly turned to stone.

With help from the gods — who loaned him such items as a cap of invisibility and a pair of winged sandals — and after a series of strange adventures, Perseus found Medusa and beheaded her. He was able to avoid the usual penalty by looking only at Medusa's reflection in his polished shield before cutting off her head. As her blood dripped to the ground, it slowly formed into the winged horse Pegasus — who flew away and has no further connection with the story.

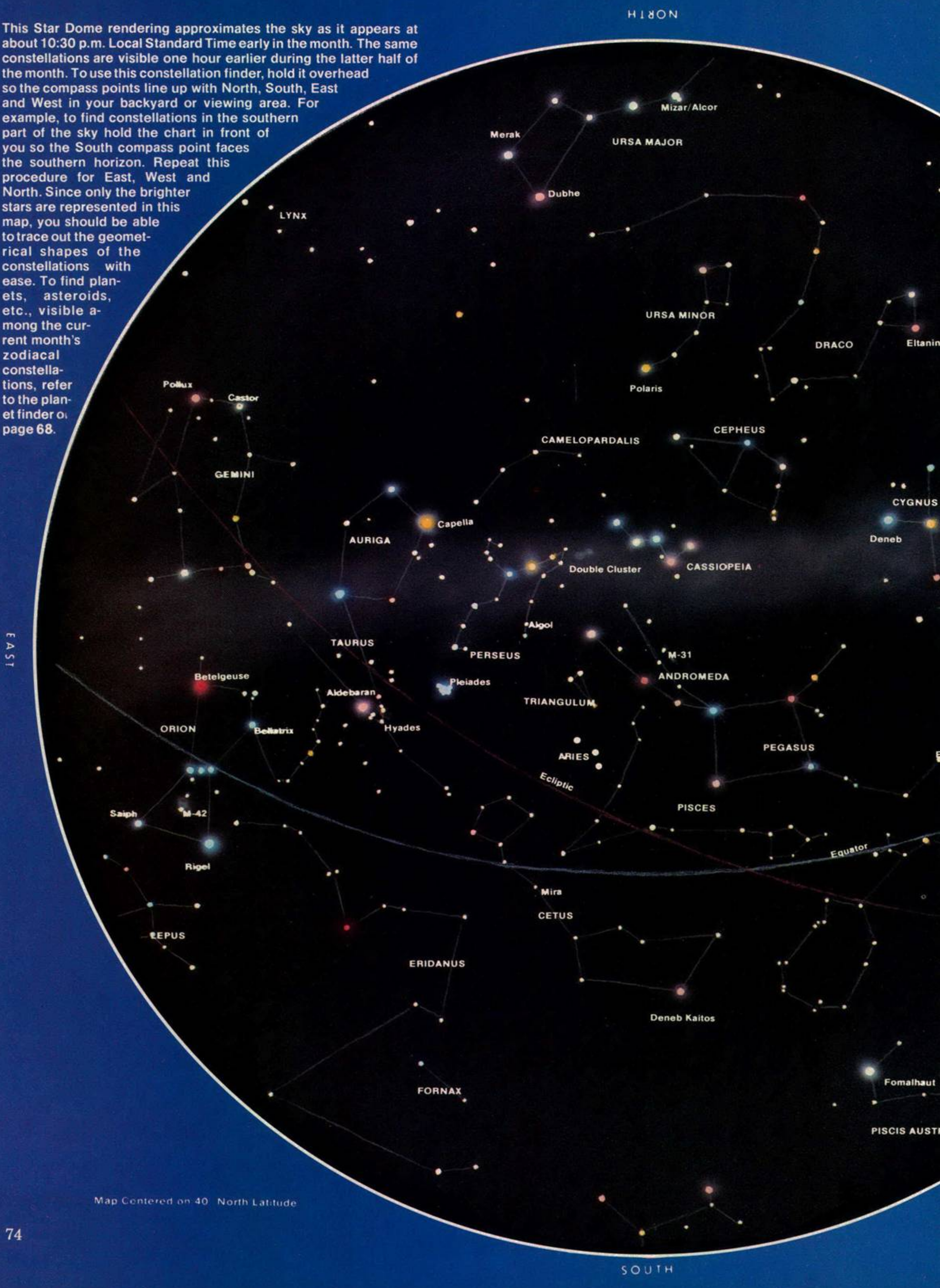
At this point, the other characters in the myth make their entrance. Probably this part of the story was independent at one time, and was later included in the Perseus myth. As Perseus was flying home, he passed the coast of Joppa (later versions of the myth make the locale Ethiopia), where he saw a lovely girl chained to the rocks. Curious, Perseus landed to find out what was happening. He learned from Cepheus, the king of the land, that his wife, Cassiopeia, a vain and silly creature, had boasted that she was more beautiful than the Nereids (nymphs of the ocean). Taking offense, the nymphs complained to their father Poseidon, the sea god, who sent various plagues and storms upon the kingdom, and finally decreed that only the sacrifice of the royal couple's daughter Andromeda to a sea monster would placate the Nereids.

With Cassiopeia's urging, Cepheus (the original henpecked husband) agreed to obey the decree. Chaining his daughter to the rocks, he left her to her fate. Perseus, however, promised to save her in exchange for her hand in marriage. Cepheus agreed, and after a terrific battle with the monster, Perseus killed it with his sword. (Perseus did not turn the monster to stone with Medusa's head — a small detail that nevertheless increases the likelihood of this section being a later addition to Perseus' story.)

The subsequent wedding feast was interrupted by Andromeda's uncle and promised husband, but Perseus held up the Gorgon's head, and the uncle and all his followers were turned to stone. A similar fate met Polydectes who, upon Perseus' return, sneeringly asked for the head; Perseus showed it to him. Finally, the hero accidentally fulfilled the oracle pronounced at his birth, for he accidentally killed Acrisius at a series of funeral games, when the discus he threw went out of control and struck the old man in the head.

More than any other Greek myth, this story reads like a central European fairy tale — the dangerous quest, the magic gifts, the rescue of the beautiful princess, and the coming of age of a young man are all typical motifs of folktales. To students of mythology, however, the most interesting person in the story is Medusa. The figure of the Gorgon is older than any of the other characters in the myth, and representations of Gorgons can be found in the most ancient Greek sculptures; Gorgonlike figures are also seen in Mesopotamian art. A modern interpretation of her ability to turn men to stone is that she

This Star Dome rendering approximates the sky as it appears at about 10:30 p.m. Local Standard Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder on **page 68**.


NORTH
Mizar/Alcor
Merak
URSA MAJOR
Dubhe
LYNX
URSA MINOR
DRACO
Eltanin
Polaris
Pollux
Castor
CEPHEUS
CAMELOPARDALIS
GEMINI
CYGNUS
Capella
Deneb
AURIGA
Double Cluster
CASSIOPEIA
Algol
EAST
TAURUS
M-31
PERSEUS
Betelgeuse
Pleiades
ANDROMEDA
Aldebaran
TRIANGULUM
ORION
Bellatrix
Hyades
PEGASUS
ARIES
Ecliptic
Saiph
M-42
PISCES
Equator
Rigel
Mira
CETUS
LEPUS
ERIDANUS
Deneb Kaitos
Fomalhaut
FORNAX
PISCIS AUST
SOUTH

Map Centered on 40 North Latitude

M-13
HERCULES
Vega
LYRA
Albireo
DELPHINUS
Altair
AQUILA
AQUARIUS
CAPRICORNUS
S
WEST

Map by Adolf Schaller

represents nightmares, which "freeze the blood".

But how did these characters come to be represented among the constellations? Again, Medusa is the pivotal figure. Look at the star known today as Beta Persei. This star shines steadily at magnitude 2.3 most of the time. But every 2-1/2 days, it sinks in only five hours to magnitude 3.5, and then returns to normal in the same amount of time. The ancients, of course, had no telescopes; this was the only star known to them that visibly changed its brightness, and it became known as Al Ghul, the demon (our modern Algol) — an evil, unlucky star. It was only natural that it came to represent the Gorgon's head.

With this in mind, we can discover what other factors caused the Greeks to identify the constellations as they did. Cassiopeia is a circumpolar constellation that spends half the year "upside-down"; obviously, the queen is being punished for her vanity. Cepheus, the least important person in the story, has the dimmest stars. Andromeda lies horizontally across the sky, and is represented as being chained to the rock, passively awaiting her death. The huge sea monster can only be the gigantic constellation Cetus, swimming in the depths of the celestial sea.

And Perseus himself? He is the hero of the story, and therefore possesses the brightest of all these star groups. Clutched in his hand is still the severed head of Medusa, winking balefully at us across centuries of time and light-years of space.

So our original question remains unanswered. Did the stars suggest the myth, or was the myth immortalized in the stars — or were they, perhaps, simultaneous?

A few words about Cetus, this month's Close-Up region, are in order. The word Cetus means whale (whales are classified by zoologists in the order Cetacea), but old maps and charts show a creature here that looks nothing like any whale that ever existed. Albrecht Dürer's illustration in Johann Bayer's **Uranometria** of 1603 shows a big ugly beast bearing tusks and an evil expression, with a pair of huge paws dangling in the neighboring river Eridanus. A circle of five stars between Pisces and Taurus marks the head; the rest of the animal's body swings south and west beneath Pisces. The ecliptic — the path along which sun, moon and planets travel — just misses passing through a corner of Cetus, and occasionally one of the planets lies inside its boundaries.

Cetus' brightest star is second magnitude Deneb Kaitos (Beta Ceti); a line drawn through the eastern stars of the Great Square of Pegasus points near it. The star is also known as Diphda, after an Arabian word meaning frog. Arabian astronomers depicted a swarm of little frogs in this region of the sky.

South of Cetus is the constellation Sculptor, "invented" in the 18th century by LaCaille, who called it l'Atelier du Sculpteur, the sculptor's workshop. Among its few claims to fame is the presence within its borders of the South Galactic Pole. When we are looking at Sculptor, we are looking at right angles to the Milky Way and into intergalactic space.

Close-Up

Cetus Region

The largest of the so-called "watery" constellations, giant Cetus the whale, ranks fourth in order of size among recognized star groups. Despite its impressive extent of well over 1,200 square degrees, it's rather inconspicuous to the unaided eye, having only one star as bright as second magnitude.

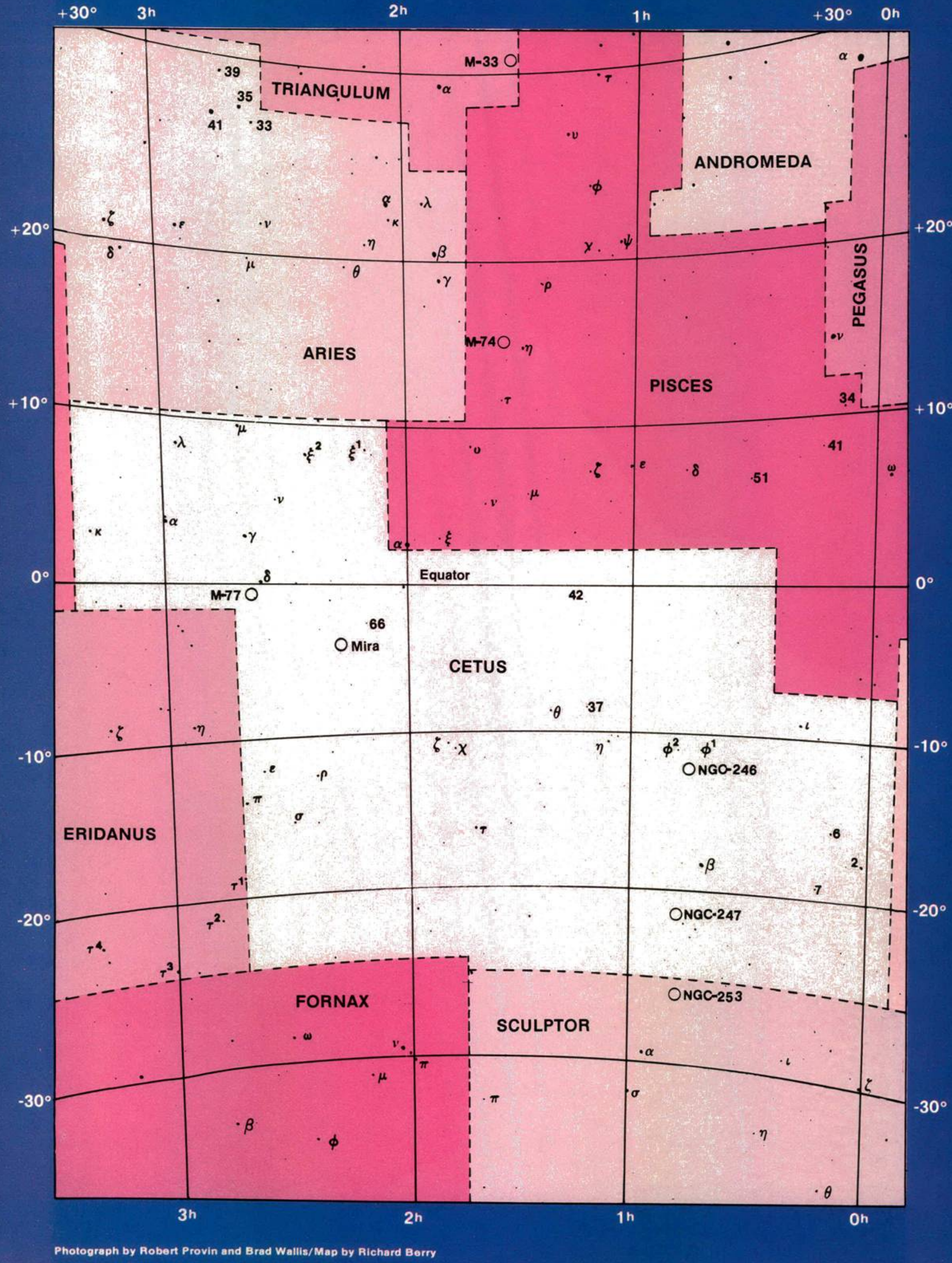
Most of the large rambling constellations suffer from this apparent lack of visual luster. Rather than discouraging the telescope user, however, this should be taken as an invitation to explore where few ever bother to tread.

In his classic **1001 Celestial Wonders**, Barns tells us that Cetus is "a broad-ranged equatorial constellation finely placed for leisurely gem-hunting". Indeed, there is much to see here even with binoculars. Take, for example, the waxing and waning of the majestic variable star Mira (Omicron Ceti), described in detail below.

Another attraction is the star Beta Ceti, located near the southern border of the constellation. Barns describes this as a "vibrating, colorful star", and so it is in binoculars — especially on transparent nights when image steadiness is poor. At magnitude 2.2, this K type orange sun outshines Alpha Ceti by half a magnitude.

Alpha itself is situated in the whale's head, and is a neat double star for binocular users. It consists of 2.8 magnitude orange Alpha and a 5.6 magnitude blue field star (93 Ceti) some 15 minutes of arc apart. Too wide for ordinary telescopic views, this pair is a striking sight in binoculars and finders.

Webb comments that Alpha "is worth looking at, as a fine combination


+30°
3h
2h
1h
+30°
0h
+20°
+10°
0°
-10°
-20°
-30°
TRIANGULUM
ANDROMEDA
PEGASUS
ARIES
PISCES
CETUS
ERIDANUS
FORNAX
SCULPTOR
M-33
M-74
M-77
Mira
NGC-246
NGC-247
NGC-253
Equator
39
35
41
33
34
41
51
42
66
37
6
2
7

Photograph by Robert Provin and Brad Wallis/Map by Richard Berry

of a beautiful orange star with a fine blue." Their respective spectral types are a high contrast M and B, agreeing well with the visual hues. If the two stars were separated by 15 seconds instead of 15 minutes, Alpha would rank as one of the finest and brightest doubles in the sky! The stars do not form a true binary, however; the two are at different distances from us and moving in opposite directions in space.

Still another target for binoculars is the chain of fifth and sixth magnitude stars located north of Beta Ceti. This is composed of Phi-1, Phi-2, Phi-3 and Phi-4 Ceti, and extends roughly east-west in a line some four degrees long. Barns calls this asterism a "royal procession of stellar nobles".

Gamma (γ) Ceti

We begin our telescopic survey of this month's region with a stunning binary star in which the two suns are in orbital motion about each other. This is fourth magnitude Gamma Ceti just five degrees west of Alpha (α).

The duo is formed by 3.7 and 6.4 magnitude suns a tight three seconds apart. Given good seeing (image steadiness), a three inch refractor splits them nicely at about 100 power as shown in our drawing.

A color difference is definitely present in this system, but it is subtle and becomes more obvious as telescope aperture increases. Olcott describes Gamma as "Yellow-blue. Finest double in this region" with a three inch refractor, and Barns dubs it a "colorful pair" in his 10 inch reflector. Other remarks by past observers include "beautiful" and "curious colors".

While most see the primary star as pale yellow in hue, the secondary has been described by various observers as lucid blue, grayish, ashen, tawny, ruddy or dusky and even olive green! Perhaps the most apt description for this pair is pale yellow and ashen. What colors do you see in your telescope?

Omicron (ο) Ceti

We now turn our attention from stellar duplicity to stellar variability. A real showpiece of this region — at least for patient sky watchers — is the amazing variable star Omicron Ceti. A line from Alpha through Delta (δ) Ceti extended its length southwest points to this object's position in the sky.

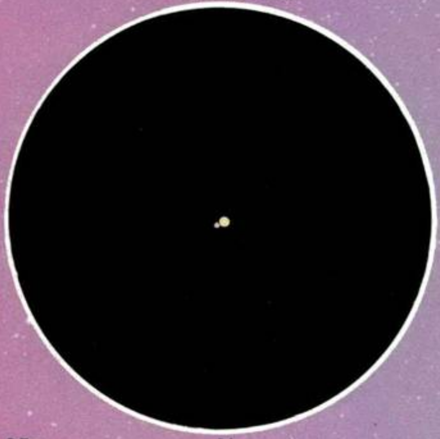
This pulsating supergiant sun is also known as Mira (Latin for "wonderful"). Discovered in 1596 by David Fabricius (who thought it was a nova because it soon disappeared), it went unnoticed until 1609, when a stunned Fabricius saw it again! After naming it "Stella Mira", Fabricius found that it had been charted in 1603 by Bayer who, ignorant of its variability, designated it fourth magnitude.

Mira may or may not be visible at its indicated position, depending on just what part of its light cycle it happens to be at. It has a nominal visual brightness range from about second at maximum to an invisible 10th magnitude at minimum in a period lasting about 332 days. Mira's last maximum occurred in January 1976; after an eight month fade to minimum, Mira is currently brightening toward another peak, which it is expected to reach around Christmas. Stars exhibiting this slow cyclical type of behavior are known as "Mira type variables" in honor of Omicron Ceti.

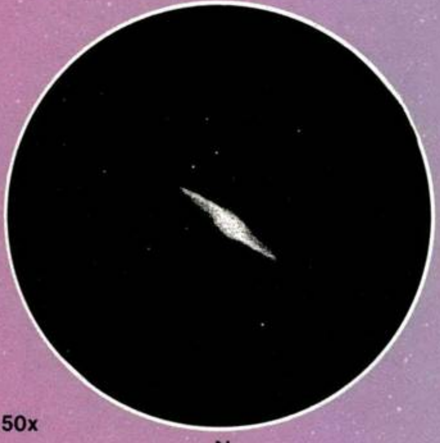
Although in recent years Mira's mean maximum light has been near third magnitude, the actual values of both maximum and minimum can vary greatly from cycle to cycle. Mira has even become one of the brightest stars in the sky. Sir William Herschel observed it as brilliant as Aldebaran in 1779, but just four years later it was invisible at minimum light even in his great telescopes!

Mira is of spectral type M, and most observers see it as a deep reddish orange in color. Webb tells us that John Herschel (William's son) called the tint "very full ruby" — but that he, himself, strangely could see no trace of red in the year 1878. Logging the visual hue of Mira from maximum to minimum and back makes an inter-

Gamma Ceti



NGC-253



Top left: Most observers have described the primary star in Gamma Ceti as yellow, but the companion has been called everything from deep blue to olive green. A three inch refractor at 95 power should show the close pair (separation, three seconds of arc) as yellow and ashen. The field of view is 1/2 degree. Bottom left: The largest and brightest spiral galaxy in the sky, aside from M-31 in Andromeda, is NGC-253 in the constellation sculptor. We on Earth view this galaxy almost edge-on; the view in a six inch reflector at 50 power shows the nuclear bulge and the spiral arms on either side. Twenty-five minutes of arc in extent, NGC-253 is the brightest member of the Sculptor galaxy cluster. Drawings by James Mullaney.

Selected Objects — Cetus Region

Object	Type	Mag.	Size/ Sep.	R.A. (1950)	Dec.
CETUS					
NGC-246	P1	8.5	240"x210"	00^h45^m	-12°09'
NGC-247	Sp	10	18' x 4'	00^h45^m	-21°01'
37 Ceti	★2	5.2,7.8	50"	01^h12^m	-08°11'
42 Ceti	★2	6.4,7.3	1.6"	01^h17^m	-00°46'
* τ (Tau)	G	3.6	—	01^h42^m	-16°12'
66 Ceti	★2	5.7,7.7	16"	02^h10^m	-02°38'
* ο(Omicron)	V:332d	2.0-10	—	02^h17^m	-03°12'
* M-77	Sp	8.9	6'x 5'	02^h40^m	-00°14'
* γ(Gamma)	★2	3.7,6.4	3"	02^h41^m	+03°02'
* α(Alpha)	★2	2.8,5.6	15'	03^h00^m	+03°54'
SCULPTOR					
* NGC-253	Sp	8.9	25'x 5'	00^h45^m	-25°34'

* Detailed in Close-Up

★2 = Double Star
P1 = Planetary Nebula
Sp = Spiral Galaxy
G = Sol-type Star
Mag. = Magnitude
Sep. = Separation
V:#d = Variable Star, period (days)

esting project for the observer who enjoys variable stars. The entire cycle can normally be followed in a three inch telescope; color studies near minimum light are best done with at least six inches of aperture.

Another feature of interest to well-equipped observers is the tiny bluish companion to Mira — an elusive object only 10th magnitude in brightness and less than a second of arc distant from its primary. Near Mira's maximum, the companion is extremely difficult to detect, due to glare from the bright primary. At other times it can be picked up in a really good 10 inch instrument at high power if seeing is better than average. It's thrilling to watch giant Mira fade in brightness until it matches its tiny companion in luster — a feat few visual observers have undertaken.

Should you be unable to detect Mira's real companion, there is an eighth magnitude field star situated about 115 seconds from the variable. This requires much less optical aid to glimpse and serves as a convenient reference star as Mira heads toward minimum light.

Both theory and observation indicate that Mira is at least 500 times the diameter of our sun at maximum expansion. Like most supergiants, its outer atmosphere is a vacuum by our terrestrial standards, and is so cool that water in the vapor state can be found in huge quantities.

Barns describes this scene with his usual great charm: "A vast aggregation of nothingness in whose torrid temperatures . . . we might imagine a soul wandering for ages and never know he had arrived." This amazing variable binary system lies about 250 light-years from us.

M-77

We move now from the individual stars of Cetus to entire universes of stars: the distant and challenging galaxies of this month's extensive region. The most prominent star city in Cetus itself is M-77, located a degree southeast of Delta.

Of ninth magnitude visually and only six by five minutes in size, this softly glowing orb is difficult to see in average finders most nights. It is better to sweep with your telescope itself, using a low power, wide field eyepiece covering at least one degree of sky. Set on Delta Ceti, and then move slightly south and east to pick it up.

Webb described M-77 as "Small, faintish; very near ninth magnitude star" and Barns gives it as "Faint, but interesting." While this remote spiral can be seen in three and four inch telescopes, at least six or eight inches of aperture is needed for a good view. Some observers feel its apparent size at the eyepiece is much smaller than the figures above suggest.

The field surrounding M-77 is peppered with a number of fainter galaxies that you may come across while sweeping for M-77. The brightest is NGC-1055, located about a degree north of M-77; it is seven by two minutes in extent, and 11th magnitude. Another is NGC-1087, 1-1/2 degrees southeast of M-77, two by one minute in size, and about 12th magnitude. As always, roaming for galaxies requires a dark transparent night, use of averted vision, and a good atlas.

NGC-253

Perhaps the finest galaxy in the sky for northern hemisphere observers (after M-31 in Andromeda) is a seldom visited object just across the Cetus border in neighboring Sculptor. This is NGC-253, easily visible in finders and binoculars on dark nights. Located seven degrees south and slightly east of Beta (β) Ceti (Barns' "vibrating, colorful star"), NGC-253 is very near the south pole of our own Milky Way galaxy.

This huge spiral shines at somewhere between eighth and ninth magnitudes (these figures are uncertain), and extends 25 by 5 minutes across the sky. Although large and bright for a galaxy, it requires a really first-class night to fully appreciate it due to its low southerly declination of -25 degrees. Many observers have likened it to a smaller version of the Andromeda galaxy — and so it looks. The apparent size difference is mostly the result of distance rather than spacial extent; NGC-253 is more than seven million light-years from us — at least three times the distance of M-31.

Often called a "beautiful spiral", this island universe was discovered in 1783 by Caroline Herschel (Sir William's sister). Most see it as long and narrow with a bright nucleus and extensions along the arms, as shown in our drawing. A four inch scope at 45 to 60 power gives a striking view on a good night, and larger apertures increase its magnificence greatly. Even Webb, from the high latitude of the British Isles, recorded NGC-253 as a "very bright and large nebula". For best results, observe it when it's directly on or very near the meridian (its highest point in the sky).

This colossal pinwheel of stars contains hundreds of billions of suns, all in motion about its dense core. It provides ample food for leisurely thought as it serenely sails the "ocean of night" — far removed from man's affairs on this planet.

Tau (τ) Ceti

We end this month's tour with a look at one of the most famous and potentially important stars anywhere in the heavens — third magnitude Tau Ceti, located 15 degrees (one hour of right ascension) east of Beta. A line through Beta and Gamma Arietis, extended about 35 degrees due south, points to its place.

This object has little to show through the telescope, for it is not double, variable, or even strongly colored. Instead, Tau's claim to fame is that it was one of the two original Ozma stars — those monitored for possible intelligent radio signals during Project Ozma. For 150 hours in May, June and July 1960, astronomers at the National Radio Astronomy Observatory in Green Bank, W. Va. surveyed these stars with a large radio telescope. The result, then, was negative. Today, with vastly improved equipment, Tau Ceti is again on the search lists of several international listening programs.

The reasons for the attention being given this star are its proximity to us and its similarity to our own sun. At a distance of less than 12 light-years, it is one of our nearest stellar neighbors in space. It is also of spectral class G, the same class to which our sun belongs. Data from several different techniques of theory and observation lead astronomers to believe that nearby stars like Tau Ceti, Epsilon (ϵ) Eridani, 61 Cygni and Barnard's star (stars of main sequence spectral classes G, K and M) are likely to have planetary systems. These factors combine to give such objects a very high priority in the search for life beyond our solar system.

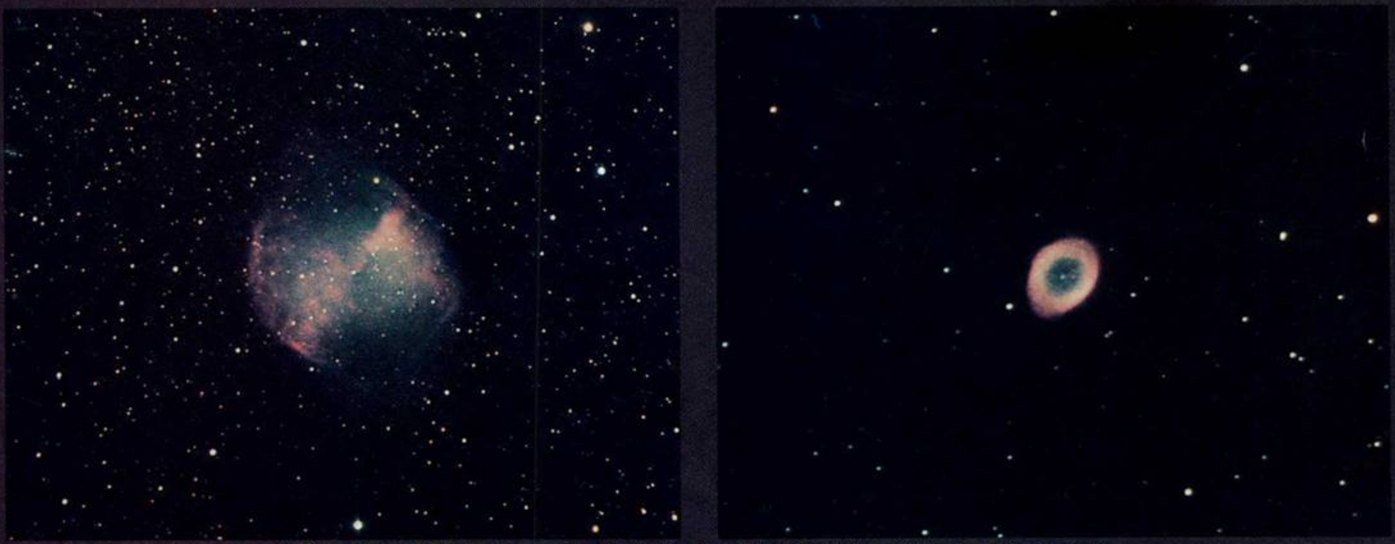
Although showing nothing worthy of ordinary telescopic scrutiny, it is still thrilling to look at Tau Ceti and consider that, within the glare of its light, alien planets (perhaps even alien civilizations) exist. As we have pointed out before, when at the telescope it is important to see with our mind as well as with our eye.

To most, the concept of intelligent life existing elsewhere in the universe is both certain and exciting. As famed astronomer/exobiologist Carl Sagan has expressed it, this is truly "an idea whose time has come". Most who have considered the possibility feel that eventual contact with alien intelligences will have a beneficial and uplifting effect on mankind. Astronomy lovers especially seem to think this way — perhaps because of our nightly contact with the majesty of the universe.

Some, however, are not only pessimistic but even cynical about the prospects. As Thomas Carlyle expressed it: "A sad spectacle. If they be inhabited, what a scope for misery and folly. If they be not inhabited, what a waste of space."

Celestron 5 Photographs: Left, the Double Cluster in Perseus; Right, Galaxy M 33

Celestron 8 Photographs: Left, the Trifid Nebula; Right, the Omega Nebula



Celestron 14 Photographs: Left, the Dumbbell Nebula; Right, the Ring Nebula

Photographs by Leo C. Henzl, Jr.

Ever wonder why most telescope manufacturers only show you pictures of telescopes in their ads?

(Compare our catalog with theirs and you'll see why.)

Celestron International
2835 Columbia St., Box 3578-AM
Torrance, California 90503, U.S.A.
Telephone: (213) 328-9560

Celestron